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Shelf rockfish stock assessment for 1997 and recommended yield options for 1998

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Abstract

Interim assessments are provided for silvergray, widow and canary rockfish. Recommendations for these species are unchanged from the previous year. The ranges for silvergray rockfish in PMFC Areas 3C+3D (Vancouver Island), 5A+5B (Queen Charlotte Sound), 5C+5D (Hecate Strait) and 5E (West Coast Vancouver Island) are 150-425 t, 350-700 t, 125-400 t, and 175-300 t, respectively. Landings in 1996 for the three stocks were 190, 411, 609, and 272 t. Recommended yield ranges for the canary rockfish stocks of Area 3C+3D and Area 5A+5B are unchanged at 350-525 t, and 200-400 t, respectively. Landings for the two stocks were 312 and 131 t. The recommended coastwide yield range for widow rockfish is unchanged at 1,100-3,000 t. Landings were 1,702 t in 1996.

The yield recommendation for the coastal yellowtail rockfish fishery (Areas 3D-5E) is lowered from 2,750-5,100 t to 2,000-4,025 t. Landings were 4,122 t in 1996. The change in the assessment follows a catch-age analysis which attributes the relative absence of older fish in recent years and the lack of evidence of significant recent recruitment, to a steady decline in abundance. The yield recommendation for the yellowtail rockfish stock of PMFC Area 3C fishery (south Vancouver Island) is combined with the northern Washington fishery (Areas 3C-US and 3B). The recommendation is raised from 1,000-2,000 t to 1,100-2,400 t based on a re-assessment of the stock by U.S. biologists. Landings were 4,664 in 1996. The rise in quota reflects a minor change in perception of the current biomass but, managers are advised that the assessments in both years indicated a major decline in the abundance of this stock, and other yellowtail rockfish U.S. stocks to the south.

Résumé

Des évaluations provisoires sont présentées pour le sébaste argenté, la veuve et le sébaste canari. Les recommandations visant ces espèces sont les mêmes que celles faites l'an passé. Les gammes pour le sébaste argenté dans les zones de gestion des pêches du Pacifique 3C et 3D (île de Vancouver), 5A et 5B (détroit de la Reine-Charlotte), 5C et 5D (détroit d'Hecate) et 5E (côte ouest de l'île de Vancouver) sont, respectivement, de 150-425 t, 350-700 t, 125-400 t et 175-300 t. Les débarquements de 1996 pour ces trois stocks ont été de 190, 411, 609 et 272 t. Les gammes de rendement recommandées pour les stocks de sébaste canari de 3C et 3D et de 5A et 5B demeurent inchangées à, respectivement, 350-525 t et 200-400 t. Les débarquements ont été, respectivement, de 312 et 131 t. Le rendement recommandé à l'échelle de toute la côte pour la veuve demeure le même, soit entre 1 100 et 3 000 t. Les débarquements de 1996 ont atteint 1 702 t.

Le rendement recommandé pour la pêche côtière du sébaste à bouche jaune (3D et 5E) est abaissé de 2 750-5 100 t à 2 000-4 025 t. Les débarquements ont atteint 4 122 t en 1996. La variation de l'évaluation fait suite à une analyse des prises selon l'âge qui attribue l'absence relative de poissons plus âgés au cours des dernières années et l'absence d'indice d'un recrutement récent appréciable à une baisse continue de l'abondance. Le rendement recommandé de la pêche du stock de sébaste à bouche jaune en 3C (sud de l'île de Vancouver) est combiné à celui de la pêche du nord du Washington (3C-US et 3B). La valeur recommandée est portée de 1 000-2 000 t à 1 100-2 400 t et repose sur une réévaluation du stock faite par des biologistes américains. Les débarquements ont atteint 4 664 t en 1996. L'augmentation du quota reflète une légère modification de la biomasse estimée, mais les gestionnaires sont avisés que les évaluations des deux années indiquaient une importante baisse de l'abondance de ce stock et d'autres stocks américains de sébaste à bouche rouge situés au sud.

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1. INTRODUCTION

We report interim assessments for the silvergray, widow, and canary rockfish, which include simple updating of biological and fishery data (Table 10.1). Full assessments for two yellowtail rockfish stocks are presented and summarize results of catch-at-age analysis. These stocks were chosen for more detailed analysis because, unlike other stocks, there is sufficient data to conduct these analyses, they result in larger fisheries than the other stocks, and they have recently been a source of greater contention with industry. We treat silvergray rockfish as four stocks, the south and central stocks being west coast Vancouver Island (PMFC Areas 3C+3D) and Queen Charlotte Sound (Areas 5A+5B, excluding Moresby Gully) respectively. Moresby Gully plus Hecate Strait (Areas 5C+5D) is treated as a third stock. The fishery off the west coast of the Queen Charlotte Islands (Area 5E) is treated as a fourth stock. Widow rockfish is treated as one coastwide stock. Canary rockfish are treated as two stocks, west coast Vancouver Island (Areas 3C+3D) and Queen Charlotte Sound (Areas 5A+5B, excluding Moresby Gully).

Yellowtail rockfish are treated as two stocks. The "coastal" stock extends from central Vancouver Island to the Alaska border (3D-5E). The "boundary" stock combines southern Vancouver Island (Area 1 and 3C-Canada) with northern Washington (Areas 3B and 3C-US).

Total Canadian landings for all four species was 9,570 t in 1996, 4% higher than 1995 and higher than the long-term average of 7,700 t (1980-1996) (Figure 10.1). Reported hook-and-line landings equalled 165 t in 1996, down from 243 t in 1995 (Tables 10.2). Landings and CPUE information have been updated for all nine stocks. Full analyses have been conducted on two of these stocks, the boundary and coastal stocks of yellowtail rockfish. The analysis of the coastal stock is presented herein, the analysis of the boundary stock was conducted and reported by U. S. biologists and summarized in the present document. We have used the U. S. document to frame our recommendations.

For canary and silvergray rockfish, we continue to collect a small number of biological samples. We have updated age composition information where appropriate but have conducted no new analyses. Assessments for these two species have relied on examination of gross trends in age composition data, pooled over intervals of 2-3 years, and general trends in commercial CPUE (Stanley 1993, 1995a, 1995b, 1996). While we attached significance to trends in CPUE in previous assessments, we remained sceptical over their value owing to the schooling nature of these species and questionable correlation between abundance and catch per unit of effort. Our scepticism over the value of these indices has increased in recent years as a highly dynamic management regime has eroded the comparability among years. The most recent impacts being the introduction of IVQ's and 100% observer coverage. We now attach no credibility to the trends in catch rate for any of the shelf rockfish species.

We see little point in continuing to struggle with these CPUE data, other than updating the nominal trend. We provide yearly estimates of non-qualified and 25% qualified CPUE, both the cumulative ($\Sigma C/\Sigma E$) and median CPUE based on those tows which contain the species. The references to "rolled-up" CPUE refers to the practice prior to 1991 of recording fishing logs in

groups of tows (rooled-up), as opposed to one tow per record in the database. For comparability, we provided a pseudo rolled-up version for 1991 and years following. We can not provide this estimate for the 1996 year owing to changes in the data system.

The virtual elimination of discarding of shelf rockfish (<0.5%), owing to 100% observer coverage and changes in management, introduces a small bias in the methodology we have used for quota recommendations for shelf rockfish. Industry representatives argued that since discards at sea were not included in our catch statistics, we underestimated the actual harvest. This was true, however, as long as discarding continued the industry continued to receive "credit" for the discards, since our harvest recommendations were based on "landed" catch. We have argued that, since discarding was continuing, then industry was effectively obtaining that increment because they were continuing to discard in excess of the quota recommendations.

We now assume that since discarding has virtually stopped, the actual harvest will be the same as the quota. Since the underlying logic of the following assessments is to recommend future harvests based on the impact of past harvest, we should now be raising the shelf rockfish quota recommendation by the amount the historical mean harvest would be increased were discard information available. We do not have these data and can only speculate about the approximate magnitude of the bias. We do suggest that actual discarding only became significant about 1985-1987 as trip limits were introduced and lowered quotas had an increasing impact. Discarding probably ended in 1995-1996 with assemblage management, 100% observer coverage, and permission for overages. We can therefore assume about 10 years of significant discarding. Since the yield recommendations are based on long term yields of up to 30 years, the impact has to be averaged over the whole time, and therefore less than that observed during years of peak discarding. We can also assume that while large potential overages may have been captured during this period, much of the overage may have been reported as other species.

We have indicated in Section 6.1, West Coast of the Queen Charlotte Islands, that we recommend that managers consider limited fisheries for canary, widow and yellowtail rockfish by allocating "exploratory" quotas of 200-300 t per species for these areas. These fisheries could be contingent upon 100% observer coverage and provision of biological samples for ageing. The preliminary impact of the fishery could be assessed in 3-4 years.

2. Coastwide

2.1. Widow rockfish

2.1.1. Landings and biological data

Widow rockfish landings were 1,702 in 1996 (Table 10.3, Figure 10.2), down from 1995 landings of 2,416 t and the 10-y mean of 2,438 t. The combination of sporadic availability on the grounds and difficult marketing owing to poor keeping qualities implies that landings cannot be assumed to reflect abundance. Landings from the northwest coast of Vancouver Island continue to dominate. We continue to collect and age specimens (Table 10.4) but have not conducted any

further analysis since age frequency summaries provided in Stanley (1995a). We our conducting our first experimental acoustic estimation for this species in January 1998. Results of this survey will be incorporated in the next assessment cycle.

2.1.2. Stock assessment and yield recommendation

We continue to recommend the range of 1,100-3,000 t for 1998/1999.

2.2. Yellowtail rockfish ("Coastal" stock)

2.2.1. Stock Definition

Stock structure for yellowtail rockfish was reviewed in Tagart *et al* (1997). To summarize briefly, initial genetic investigations of yellowtail rockfish (Wishard *et al.* 1980; McGauley 1991) found no differences among samples collected from California to north-central Vancouver Island. Both concluded that yellowtail rockfish should be considered one homogeneous stock within this region. Tagart, Phelps, and Stanley (pers. comm.) examined over 1000 yellowtail rockfish taken in 10 samples from five areas over two seasons. The electrophoretic analysis indicated no significant difference among Canadian samples (5A+5B, 3D) and northern Washington samples (3C). However, samples differed between northern Washington and those from southern Washington and southern Oregon.

Stanley et al (1992) examined parasite incidence and prevalence among samples from Queen Charlotte Sound to central Oregon. They found a cline of decreasing prevalence for a monogenean gill parasite (*Monogenea sebastis*) from 80-100% in the northern sample to 0-10% in the south. The results neither indicated clear boundaries nor precluded extensive mixing.

A review of tag returns from the Alaska Department of Fish and Game (ADF&G) and Fisheries and Oceans, Canada (F&O), indicates long distance movement of adult fish (Stanley *et al.* 1994). Of 550 fish tagged by ADF&G in southeastern Alaska, three were recovered near the point of tagging, and five were recovered in Queen Charlotte Sound. F&O recoveries indicated that adult sized fish could move from Queen Charlotte Sound to the south coast of B. C. Individuals tagged off the south coast of B. C. could move north to Queen Charlotte Sound (one specimen) or further to the south off southern Washington or even central Oregon. The number of returns (46) is too small to infer mixing rates but it is clear that adults can be mobile.

While we have evidence for mobility of yellowtail rockfish, the evidence falls short of suggesting one stock on the west coast of North America. We have assessed the yellowtail fishery as two stocks in B.C. We assume a "coastal" stock from the Alaska border to Area 3D (central Vancouver Island). This excludes the Canadian fishery on the south coast of Vancouver Island (Area 3C-Can). The latter fishery data are included in the U.S. stock assessment which also includes U.S. Areas 3C-US and 3B from northern Washington (Tagart 1991, 1993; Tagart and Wallace 1996, and Tagart et al 1997). We refer to this latter stock as the "boundary" stock.

We recognize the arbitrariness of this boundary, but argue it is consistent with the overall evidence. Identifying two stocks to cover the northern extent of the fishery (Canada/Alaska border) to central Washington is consistent with the evidence for mobility while acknowledges the evidence against one large homogeneous stock. Choosing a dividing line of south-central Vancouver Island is arbitrary. While it was obvious from the tagging work that fish from the U. S. and Canadian portions of 3C are one stock, and genetics indicates a reasonable southern boundary in southern Washington, we have no basis for identifying a boundary between Queen Charlotte Sound fish (5A+5B) and Area 3C fish. In the absence of a biological basis for making this choice, we set the boundary to facilitate management. The current boundary minimises joint management problems brought about by trans-boundary stocks. As discussed below, we have incorporated the fishery data for the "enigmatic' central Vancouver Island zone in such a way that managers can allocate the harvest resulting from this fishery data to either of the stocks.

2.2.2. Fishery data

Trawl landings for the coastal stock were 4,120 t in 1996, much higher than the thirty year average of 2,821 t, but approximately equal to the mean of 4,011 t over the last 10 years (Areas 3D-5E; Table 10.5 and 10.6). We indicate qualified (25%) bottom trawl CPUE ($\Sigma C/\Sigma E$ and median) for all tows with yellowtail rockfish present for both Area 5A+5B and Area 3D (Table 10.6). No strong trends are apparent in the CPUE indices except for a decline in the tow-by-tow estimates for Area 3D bottom trawl prior to 1996. We included qualified (25%) CPUE from the nominal landings in the catch-age analysis, however, we suggest that there is no basis for using it to tune the analysis (see Section 10). For baseline runs, the qualified CPUE values were input to the model but with no weighting. A 25% qualification indicates that the CPUE index is derived from only those tows for which yellowtail rockfish made up at least 25% of the retained catch.

For consistency, we focused on landings and biological data for Queen Charlotte Sound only (Areas 5A and 5B). If managers wish to generate recommendations for a larger area, circumscribing the entire coastal stock area, we provide a basis for increasing the recommendation based on historical landings (Section 2.2.6).

2.2.3. Biological data

Biological data were obtained from the GFBIO database (Pacific Biological Station, Fisheries and Oceans, Canada). We used all available aged material from Queen Charlotte Sound. These were aged using the break-and-burn method (MacLellan 1996). This included 1996 samples that had been aged by May 1, 1997 (Table 10.7, Figures 10.3). The yearly contribution of the age data in the catch-at-age analysis was weighted by the square root of the number of samples to a maximum value for 16 samples. Sixteen samples was equated with 400 fish. The weighting was calculated as follows:

$$w = 400 * \sqrt{n} / \sqrt{16}$$

where n is the number of samples. Therefore, the weighting among years is asymptotically proportional to the square root of the number of samples. Data were weighted within a year by giving equal weighting to each sample. The age data were treated as unbiased and without error.

Decreasing size-at-age in sampled landings recently has been reported for various Northern Pacific stocks (G. A. McFarlane, pers. comm.) and was apparent for this stock (Figure 10.4a and 4.5b). We therefore derived estimates of size at age for different periods based on Queen Charlotte Sound data only and input the estimates of weight at age rather than assuming constant growth over time. For each period and sex, we derived lengths by fitting the log version of the Schnute (1981) growth model:

$$\log L = \log[P_1 + (P_2 - P_1)(1 - P_3^{(A-1)}) / (1 - P_3^{(M-1)})];$$

where A is the age of the specimen and M is the maximum age in the samples (45 for females and 60 for males). The paucity of observations for some years, particularly for females and younger age classes led us to group data arbitrarily in four-year intervals until the 1995-1996 period (1979-1982, 1983-1986, 1987-1990, 1991-1994, 1995-1996) (Table 10.8 and Figures 10.5a and 10.5b).

We have too few data from this stock to derive a length/weight relationship, we therefore used the relationship derived from fish captured off the Washington-California coast (Tagart 1991):

$$w_g = 0.0185 l_{cm}^{2.959}$$

Tagart (1997) noted that the relationship does not vary significantly among regions, years, or season of year.

The model features and formulation are summarized in Appendices 1 and 2. We assumed sex-specific natural mortality owing the relative absence of older females. Following Tagart et al (1997), M was constant for males, while female M was equal to male M until the age of 10 at which point was allowed to increase linearly with age until the accumulator age. The slope of the rate of change of female M for the older fish was fit by the model on each run.

In our baseline run, we parameterized selectivity as a function of age, constant over time and the same between sexes, except for later runs where the accumulator final age class (19+) allowed male and female selectivity to differ. We assumed no stock/recruitment relationship. Recruitment for each year was estimated by the model except that the most recent two years were fixed to be equal to the mean of all the preceding years. The model is indexed for years 1979-1996 and for ages 6 to 19+.

2.2.4. Results

The initial runs indicated a declining biomass in response to the progressive elimination of older age classes in the samples (Figure 10.6: panel 1,1). While the analysis in previous years tended to provide little guidance as to whether the absence of older fish was caused by declining

abundance or high recent recruitment, the current model and addition of more years of age composition, seems to find no basis for assuming relatively high recruitment in recent years. The 1987 yearclass appeared above average (6-year-olds in 1993) but not large enough to compensate for the adjacent poor yearclasses.

The baseline model provided an adequate fit to age composition data (Figure 10.6: panels 3,2 and 3,3; and Figures 10.7a and 10.7b), especially for years with adequate sampling. The standard normal residuals of Figures 10.7 equal:

$$residual_{ijs} = (p_{ijs} - o_{ijs}) / (p_{ijs}(1 - p_{ijs}) / \sqrt{n})$$

where p_{ijs} is the predicted and o_{ijs} is observed proportion at age i, year j, and sex s. There are no consistent patterns in the distribution of residuals.

However, while initial runs converged, they indicated an unrealistically low estimate of current biomass, approximately equal to the recent harvest. Similarly, the likelihood profile reflects what appear to be overly precise confidence bounds. We examined the effect of constraining F in 1996, by using penalty weights to force F for 10 year-old females ($F_{96,f10}$). This effectively provides the model with an estimate of biomass in 1996. Increasing F leads to the predictable effect of scaling terminal biomass (Table 10.9). It shows that the age likelihood is minimised for very high values of $F_{96,f10}$, between 0.50 - 1.00. These are associated with declines in exploitable biomass to 7-12% of the starting biomass. The fit to ageing data (age likelihood) begins to degrade rapidly with $F_{96,f10}$'s less than 0.30.

We examined the sensitivity of these baseline results to other main assumptions in the model, natural mortality and selectivity. To make the model more able to respond to different parameterizations, we removed the constraint on F. We varied M in fixed increments (Table 10.10). Varying M altered the estimate of 1979 exploitable biomass but for all values continued to indicate declining abundance.

The observed change in the age composition towards younger fish can be attributed not only to declining abundance but also to a change in selectivity or introduction of a sampling bias. We explored this by allowing the model to account for the increased proportion of younger fish in recent years through fitting a second period of selectivity for fish younger than 13 years. Selectivity for 13 and over were allowed to vary over age but were kept constant over time. The additional selectivity period added 7 parameters. The model responded by estimating higher relative selectivities for younger fish in the recent years (Figure 10.8). The best fit was associated with dividing the time series between 1992 and 1993 (Table 10.11). We then re-conducted the runs while varying $F_{96,f10}$. The effect was a improvement in the fit to the age likelihood (Tables 10.9 and 10. 12) and a significant increase in biomass. However, it did little to reduce the tendency for the model to indicate rapidly declining exploitable biomass. Figure 10.9 summarises the trends in terminal exploitable biomass and the age likelihood over varying $F_{96,f10}$ with the two selectivity periods.

A change in "selectivity", as it is parameterized in the model, could result from a sampling bias towards sampling boats that fish shallower waters. It could represent a change in the distribution

of the stock with respect to age such that older fish moved to unfished grounds or depths. Tagart et al (1997) investigated these possibilities in attempting to account for a similar trend towards younger fish in the U. S. yellowtail rockfish samples, but no found no evidence of such a bias. If recruitment to the grounds is size dependent rather than age, then a change in growth rate could account for the change in selectivity. However, the recent trend is towards smaller size at age is in apparent contrast to the "fitted" change in selectivity. It is not surprising that the fit improved after providing increased latitude to the model in the form of two selectivity periods. It is surprising that it did not make a bigger impact on the biomass trajectory.

We examined the impact of tuning the model to a CPUE trend shown as the observed trend in panel 1,3 of Figure 10.6). The results echoed the effect of varying F. As the rising penalty weight led the model to track the CPUE trend more closely, the fit to the age data deteriorated more rapidly and the model runs indicated a more optimistic scenario (Figures 10.10). We also examined the impact of reducing the input values for samples sizes to 50% of the calculated weighting. This did not affect the general behaviour of the model.

2.2.5. Assessment

This analysis is consistent in indicating a declining biomass but we have no objective basis for determining the degree of decline or the size of the current biomass. The best fit of the model results in terminal exploitable biomass which appears implausible (Figure 10.6, Table 10.9). More plausible terminal biomasses result from runs which imply declines to 20%-70% of the 1979 exploitable biomass, however as terminal exploitable biomass increases it is associated with degrading fit to the age composition data. Thus, plausibility is achieved by forcing the model to ignore the age composition data, the only reliable information we have on this stock.

The decline seems to have resulted from poor recent recruitment (excluding the 1987 yearclass) and may have been exacerbated by fishing, although the latter assumption cannot be resolved by this analysis. Since we lack any accurate basis for current biomass, we are not in a position to provide any meaningful forecasting.

2.2.6. Yield recommendation

In spite of the stable performance of this model, the lack of an auxiliary tuning index leaves little objective basis for a precise harvest recommendation. Nevertheless, the age composition does provide a strong signal that population has declined significantly since 1979. While it is unclear to what extent this decline is fishery or naturally induced, we recommend against harvest levels that were coincident with the apparent decline. We therefore view as high risk any harvests equal to or above recent past harvests (10-year mean). Depending on the management boundaries, this translates to approximately 1,900 t for Areas 5A+5B only, the area circumscribed by the landings and age composition data used in this analysis. If managers wish to apply a yellowtail rockfish quota to a larger area, then the same derivation would indicate 2,300 t if Areas 5C-5E are appended to 5A+5B and 4,025 if Area 3D is also included. We suggest a conservative approach would be to harvest 50% of the 10-year mean or 950, 1150, and 2,000 t respectively, depending on the combination of areas.

3. WEST COAST VANCOUVER ISLAND (AREAS 3C+3D)

3.1. Silvergray rockfish

3.1.1. Landings and biological data

Total landings of silvergray rockfish were 199 t in 1996, of which 9 t were reported for hook-and-line gear (Tables 10.2 and Table 10.13, Figures 10.11 and 10.12). This was a significant drop from the 10-y average of 585 t and 30-year average of 544 t. Total landings had been relatively stable from 1991-1995 in the 400-600 t range. They exceeded the high risk recommendations 1993-1995.

Non-qualified CPUE has declined steadily since the advent of the Canadian trawl fishery in 1983. The qualified index appears to be stable or declining slightly. Median CPUE is without trend through 1995. No new biological information has been examined since the last assessment (Table 10.14).

3.1.2. Yield recommendations

The current yield range of 150-425 t, corresponding approximately to 25% and 75% of the long-term yield was first proposed in 1992 (Stanley 1993) in response to declining CPUE and an indication in the age composition data that the estimate of Z for males implied an F 2-3 times in excess of published estimates of M. From 1993-1995, the CPUE trends have been downwards except for median CPUE which shows no trend. Without any positive sign in the CPUE indices and no additional ageing information, we see no basis for changing the recommendation. We continue to recommend a yield range of 150-425 t, 25% - 75% of the long term yield. We draw attention of the managers to the impact of discarding on the quota recommendations.

3.2. Yellowtail rockfish ("Boundary" stock, Areas 1, 3B+3C)

3.2.1. Landings

This stock is harvested jointly with U.S. fishers. Much of both nation's harvest is generated as bycatch in the joint-venture and domestic hake fisheries (Table 10.15, Figures 10.13 and 10.14). Total harvest in 1996 was 4,664 t, the highest on record, over twice as high as the average combined harvest of 2,102 t prior to that year (1967-1995). Canadian harvest has averaged 495 t over the whole period but 1,070 t, over the last 10 years, with half of that as bycatch from the offshore hake fishery. Canadian domestic trawl landings were 1,254 t in 1995, the highest on record, and related to the result of increased domestic landings of hake. The joint-venture hake fishery in Canadian waters yielded 980 t of yellowtail rockfish bycatch in 1996. Most of the landings by Canadian domestic trawl results from midwater fishing thus CPUE for the Canadian fishery is meaningless as an index of abundance.

3.2.2. Assessment

3.2.2.1. U.S. assessments

In this and previous assessments, we have relied on U. S. assessments for developing yield recommendations (Tagart 1991, 1993; Tagart and Wallace 1996: Tagart *et al* 1997). All available Canadian landings and biological data are included in these assessments and we have participated informally in the analyses. The U. S. and Canadian assessment staff have then independently used the output from these analyses to frame harvest advice to their respective managers. For 1994 and 1995 harvest years, we recommended lower yields than those recommended by the author(s) of the assessment reports. While the analyses were thorough and made full use of U. S. and Canadian data, we suggested that the final basis for choosing yield recommendations, $F_{35\%}$ was overly optimistic and recommended a yield range of 1000-2000 t. The U. S. recommendation of approximately 2,000 t was used as our high-risk option.

In 1996, the U. S. assessment was far more pessimistic than previous versions as indicated in the following quote (Tagart and Wallace 1996):

> ... the 1996 fishing mortality rates were estimated to be 0.699 to 1.298. The overfishing rate of exploitation is 0.38, therefore under any model configuration, the current rates of exploitation exceed the overfishing definition. Current spawning stock biomass is estimated at 15-22% of the unfished biomass, but due to low recent recruitment, it is expected to continue to decline even under conservative exploitation rates. Mean projected yield over the next three years at the $F_{35\%}$ rate of exploitation ranges from 481 mt to 756 mt ..... The 1995 catch, including discard was 3007 mt. The spawning biomass in 1999 is projected to be only 7-12% of the unfished spawning biomass.

The model output was "driven" by two features of the source data. Firstly, as in our current coastal stock assessment, the recent years of data appear to lack the older and younger age classes, thereby leading the catch-at-age analysis to indicate high fishing mortality and poor recruitment. Secondly, the 1995 triennial survey found the lowest abundance of yellowtail rockfish in the history of the survey.

We previously suggested that the triennial survey presented a reasonable but pessimistic version and therefore was acceptable as a basis for a conservative yield option for the stock of 1000 t. Since our analysis of hake bycatch in the Canadian zone was not as pessimistic, although admittedly over a shorter time period (Stanley 1996), we recommended a high-risk option of 2000 t.

The U. S. assessment panel and industry representatives viewed the 1996 assessment as overly pessimistic and recommended higher harvests than those of the authors. They also requested a major re-assessment for the 1997 cycle. They asked that the collection of biological samples be examined for evidence of a sampling bias that could provide alternative reasons for the simultaneous disappearance of the youngest and oldest fish. They also requested that alternative

tuning indices derived from hake bycatch and domestic bottom trawl CPUE be explicitly incorporated in the analyses.

The revised assessment was completed in July this year (Tagart et al 1997). The review of biological data revealed no specific bias that could have led to the absence of the youngest and oldest age classes in the samples. The final presentation of the analysis summarises the results of three basic versions to frame the management advice. The core analysis treats the U. S. coast as one stock. The three models differ in the use of auxiliary tuning indices. All base versions of all three models imply that biomass has declined, albeit to varying amounts. Model 3 includes the triennial survey relative abundance indices and results in the most pessimistic scenario. Model 8 uses all three relative abundance indices with constant catchability for the survey and time varying catchability for the other indices. Model 1, with no tuning index and driven solely by catch-age data from the commercial fishery, produces a stock reconstruction intermediate between the other two. The three models project harvest rates under an $F_{40\%}$ strategy (the level of fishing mortality that will reduce the spawner biomass per recruit to 40% of the equilibrium unfished level) ranging from 1,850 - 4,657 coastwide. This range compares with annual harvests over the last five years of 6,300 t and last year's harvest of 8,100 t. It is our understanding at this time that the U. S. managers will be adopting 4,657 as the coastwide quota for 1998.

The authors do not report extensively on their analyses of the individual stock units but do summarize the results of these runs (Table 10.16 from Tagart et al 1997). The sum of the biomasses predicted in the individual stock models exceed the coastwide estimates. They tend to project the biggest decline for the southern-most stock and the smallest decline for the boundary stock. The variation among the results of models 1, 3, 6 (all indices used, all with constant catchability) and 8 are similar for the boundary stock. For the boundary stock , the baseline versions of models 3 and 8 produce $F_{40\%}$ harvest recommendations of 1,063 and 2,425 respectively. This is similar to the previous U. S. recommendations (1995 and 1996) for the boundary stock.

3.2.2.2. Canadian joint venture hake by-catch index

In the previous assessment, we treated the bycatch of yellowtail rockfish in the Canadian offshore hake fishery as a relative abundance index. This fishery, between 1988 and 1996, has conducted thousands of tows within relatively narrowly defined time (June-October) and space boundaries We used a subset of the observations which circumscribed an area between 125° and 125° 45' west longitude and south of 48° north latitude and north of the international boundary. The subset included approximately 85% of the observations.

We developed various abundance indices including 90% quantile of catch/tow, mean catch/tow, and a simple linear model which attempted to remove the month effect on catch. These all provided a similar result. For this assessment, we have simply shown mean catch/tow, the ratio of yellowtail rockfish/hake and 90% quantile of catch of yellowtail in all hake tows (Figure 10.15). These indices are all similar and indicate a doubling in the catch rate index. There is no basis for assuming such a dramatic rise in population for a long-lived fish with gradual

recruitment to the fishery. While in the previous assessment, the apparently stable behaviour of these indices in terms of annual changes, implied some credibility, it would appear that this index may be less useful that we thought previously. The increase in apparent abundance is coincident with major changes in hake distribution by size (Mark Saunders pers. comm.). We suggest that the increase in the index in 1996 does not imply an increase in stock abundance but is more likely related to a change in the distribution.

3.2.2.3. Inclusion of Area 3D fishery

Managers requested that we provide a yield recommendation for a combined 3C and 3D yellowtail rockfish quota. We did not conduct the overall boundary stock catch-age analysis with the additional catches or ages from the 3D fishery. We suggest that the impact of including the data would simply have scaled upwards the overall biomass by an amount approximately equal to the relative amount of additional catch (Table 10.17). Inclusion of the few age samples with the altered landings history would provide no change to the observed trend.

3.2.3. Yield recommendation

As in the previous assessment, we view the U. S. assessment as a thorough and comprehensive treatment of all available U. S. and Canadian data. We agree with the conclusions that the biomass is declining since 1990 and are concerned about the simultaneous disappearance form the samples of both young and old individuals. Similar to the U. S. staff, we are unsure about the degree of the overall decline (since 1988).

We note that the output from stock specific versions of the two models for the boundary stock of 1,063 and 2,425 provides a reasonable and objective basis for a recommendation of 1,100 - 2,400 t. This is higher than the range recommended last year 500 - 2,000, but should not be interpreted as suggesting that we believe the stock is increasing. On the contrary, given the strong signals of stock decline, we would urge managers to adopt a conservative value within the recommended range.

As in previous years, we advise managers that the mid-point of our recommendation (1,750 t) is well below the combined nation catches in previous years. We also remind managers that much of these landings result from bycatch. As evidence accumulates that this stock is in a major decline, we urge that Canadian and U. S. managers work toward some reconciliation of harvest strategy. It is becoming apparent that this stock can not continue to sustain the harvest observed in 1996 of over 4,000 t, or even the 10 year mean harvest of 3,000 t.

We know of no biological basis for allocating the harvest between nations. To assist managers in arbitration, we have included a table of historical catches (Table 10.15). We suggest managers consider the bycatches of yellowtail rockfish during the hake fisheries in their allocation discussions.

If managers wish to combine the yellowtail rockfish quotas for Area 3D with 3C, then we suggest they simply scale the above recommendation for this area, 1,063-2,400 t, by the proportion that Area 3D has provided in the catch history, approximately 30%, providing a combined recommendation of 1,400-3,120 t (Canadian and U. S. landings).

3.3. Canary rockfish (Area 3C+3D)

3.3.1. Landings

Total landings of canary rockfish from PMFC Areas 3C+3D were 312 t in 1996 (Tables 10.18, Figures 10.16 and 10.17), of which 6 t were reported from the hook-and-line fishery (Table 10.2). Total trawl landings were lower than the 30-y average (1967-1996) of 707 t. Landings exceeded the high-risk yield recommendation 1989-1995 but were under the minimum recommendation in 1996. Tow-by-tow CPUE has increased for four years Median CPUE is without trend.

3.3.2. Biological data and yield recommendation

Four samples were collected in 1995 and have been aged (Table 10.19 and Figure 10.18). The distribution appears similar to the 1993-1994 samples. The compositions do not seem to have altered since the 1982-1986 collection. While the increase in one CPUE trend is positive, we note that the recent year's increase is associated with very small landings. We continue to recommend a harvest range of approximately 50 to 75% of the historical mean, for a recommended range of 350-525 t.

4. QUEEN CHARLOTTE SOUND (AREA 5A+5B)

4.1. Silvergray rockfish

4.1.1. Landings

The total landings of 411 t (2 t hook-and-line) of silvergray rockfish in 1996 from Areas 5A+5B were below the long-term mean of 714 t (Table 10.20 and Figures 10.19 and 10.20). The nominal and qualified CPUE's remain low. The tow-by-tow index is variable. Median CPUE shows no trend from 1991-1995. The 411 t harvest was slightly above the minimum yield recommendation.

4.1.2. Biological data

Age composition information is updated to include five samples from 1995 (Figure 10.21). The age composition, which in the early 1990s, was perceived to be becoming progressively truncated, has tended to indicate a relatively large component of older fish in the two most recent years. Thus, recent observations provide no evidence that harvests of the last decade have yielded an age composition consistent with a high rate of total mortality. An alternative

explanation is that fishing mortality could be high in conjunction with consistent recruitment failure over the last 5-10 years.

4.1.3. Yield recommendations

The currently recommended yield range, corresponding to 50% and 100% of the historical mean, was based partly on the truncation of ages observed in samples from 1977-1992. It was also based on the decline in CPUE. Neither trend is apparent in recent years. It is difficult to conclude from this qualitative examination of the age composition that the historical harvests have had a significant impact. For this interim assessment, we continue to recommend the previous yield range of 350-700 t but we note that the basis for recommending the original range is less apparent. Managers may wish to consider this when choosing from within the recommended range. By the next assessment, we will have enough information to conduct a catch-age analysis and therefore a more comprehensive assessment on this stock. However, the lack of a credible tuning index, the paucity of age information, and the fact that this species is considered one of the most difficult of the rockfish to age, and therefore presumably more imprecise, implies the results will still be qualitative. We expect only a marginal improvement in our ability to provide advice for this stock, but hopefully it will provide a more objective basis.

4.2. Canary rockfish

4.2.1. Landings

Total landings equalled 131 t in 1995, (Tables 10.2 and 10.21 and Figures 10.22 and 10.23), less than one-half the long-term average of 366 t (1967-1996). The hook-and-line fishery yielded six t of the total. Landings were well below the minimum recommended yield range. Qualified, rolled-up CPUE remains low and appears to be declining. The tow-by-tow index is highly variable and the median CPUE is stable, except for the 1996 observation. However, that was based on observer only data. No new biological material was obtained in 1995 (Table 10.19)

4.2.2. Yield recommendation

The previous recommendation of 200-400 t corresponded to 50% and 100% of the historical yield. We see no reason to change from the previous rationale but note that the low landings of the last four years have led to a modest decrease in the mean historical yield. Thus the same proportions of 50% and 100 % now lead to a harvest range of 175 - 350 (rounded to nearest 50 t). We see no reason to change from the previous recommendation of 200-400 t.

5. HECATE STRAIT (AREA 5C+5D)

5.1. Silvergray rockfish

5.1.1. Landings and biological data

Total landings equalled 343 t in 1996, 28 t of which were landed by hook-and-line vessels (Tables 10.2 and 10.22, Figures 10.24 and 10.25), less than the mean trawl landings of 606 t over the last 10 years, but approximately equal to the mean landings of 363 t since the advent of this fishery in 1979. Nominal CPUE (qualified and non-qualified) appears to have stabilised since the significant decline following 1986. Tow-by-tow CPUE appears to be increasing but this appears correlated with landings. Median CPUE is without trend. Recent age composition data has been added (Figure 10.26). The trend towards truncation of the age composition that was observed in comparison of 1977 to the 1992-1993 samples, is supported in 1994-1995 samples.

5.1.2. Yield recommendation

The process of truncation appears more gradual that at first observed during the early part of the fishery. For this interim assessment, we continue to recommend 125-400 t, 25% and 75% of the historical yield. We will be conducting a preliminary catch-age analysis for the next assessment cycle. However, the lack of a credible tuning index, the paucity of age information, and the difficulty in ageing this species implies that the results will still be qualitative. We expect only a marginal improvement in our ability to provide advice for this stock, but it should provide a more objective basis.

5.2. Canary rockfish

The canary rockfish fishery in Hecate Strait continues to be minor.

6. AREA 5E (WEST COAST OF THE QUEEN CHARLOTTE ISLANDS)

6.1. Widow, yellowtail and canary rockfish

The widow, yellowtail, and canary rockfish fisheries off the west coast of the Queen Charlotte Islands continue to be minor. Yield recommendations are not presented for these species. We note industry concerns over possible yields that could be removed from this area without affecting populations on the traditional grounds. While we have no objective basis for identifying stock boundaries, we suggest that there is a reasonable likelihood that canary rockfish, off the west coast of the Queen Charlotte Islands, could be separate from the traditional stocks.

We note that the recent slope rockfish survey was successful in obtaining numerous samples of canary rockfish. Since we have 100% observer coverage in the trawl fishery, we suggest that

managers may wish to implement interim quotas for canary rockfish in this area under the restriction that observers be allowed to obtain otolith samples from significant catches. For purposes of discussion, we suggest an interim quota in the range of 200-300 t.

We view yellowtail and widow rockfish as less likely to be distinct stocks from the remainder of the coast, however, a small experimental quota under the same restrictions might be considered to ascertain whether the age composition of these stocks are the same as the rest of the coast. For purposes of discussion, we also recommend consideration of interim quotas of 200-300 t for these two species in this area.

6.2. Silvergray rockfish

6.2.1. Landings, biological data and assessment

Combined landings for all minor areas of Area 5E were 206 t from the trawl fishery and 66 t from the hook-and-line fishery (Table 10.23). In the previous assessment, we recommended adopting a quota of 175-300 t for the combined region. This recommendation was imposed for the 1997-1998 fishing year as a quota of 273 t. Landings in 1996 were 66 t from hook-and-line fishery and 216 t from the trawl fishery We reviewed the available age material in the previous assessment, no new material has been obtained. We continue to recommend a yield range of 175-300 t which represents 75 and 125% of the mean yield of 218 t over the last 20 years.

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8. APPENDIX Catch-at-age model

8.1. Summary of features.

Item	Description
Landings and effort	Landings data (1979-1995) from GFCATCH database Fisheries and Oceans, Canada. 1996 data from observer data provided from Archipelago Marine Research database. CPUE for 1979-1995 from 25% qualified, "rolled-up" observations. 1996 CPUE from tow-by-tow data
Ages	Break-and-burn ages, 1979-1996 (no samples for 1981,1984, and 1987). First age equalled 6, older ages were grouped at 19+.
Growth	Length, age and maturity data from GFBIO database at Fisheries and Oceans. Restricted to samples from Queen Charlotte Sound. Weight-age values were calculated separately for 5 different periods.
Length/weight	From Washington coast biological data Tagart (1991).
M	Instantaneous natural mortality rate constant over age (6-19+) for males, female M equal and constant to males for ages 6 - 10. M for females > 10 increasing linearly to 19+. The model allowed to fit the slope of M for older females
Stock/recruitment	The s/r relationship is not paramterized in the model. Each recruiting year estimated by the model except the two most recent, which were set equal to the mean of the preceding years.
Selectivity	Various parameterization. Final runs set sexes equal except for 19+; variable by age but constant over time for ages 13-19+; ages 6-12 fitted separately for two periods (1979-1992;1993-1996)
F	Various parameterizations. Baseline runs allowed fit to all years and ages.

8.2. *Yellowtail rockfish catch-age model*

This appendix describes the age-structured model developed for the 1997 coastal yellowtail rockfish stock assessment. The model is based on fairly standard formulations for the catch equations and fishery selectivities. The population, and catch taken from it, is modelled as sex-specific, males and females are accounted for separately in the analysis. Although two different gear types have had significant presence in the fisheries (bottom trawl and midwater trawl), we model the catch equations for only one gear (i.e. selectivity). There is some evidence for subtle differences in the selectivity but differentiation in the data is questionable and previous work suggests that the differences do not warrant the "cost" of added complexity.

The formulation of the catch-age model assumes the multinomial distributions for the age-composition data and the log-normal distribution for other model components (Fournier and Archibald 1982). The fundamental model parameters, that is , those which are directly estimated through the minimization and from which all other model parameters can be calculated, are estimated by maximum likelihood. The model is implemented using AD MODEL BUILDER software (Otter Software 1994).

The following list defines all model parameters:

<u>Non-fundamental model parameters</u>

C_{ijs} is the predicted catch in numbers of fish of sex s and age j in year i

N_{ijs} is the estimated number of fish of sex s and age j in year i

F_{ijs} is the instantaneous fishing mortality rate for fish of sex s and age j in year i

P_{ijs} the predicted proportion of sex s fish in year i which are age j is calculated as

$$C_{ijs} \Big/ \sum_{s} \sum_{j} C_{ijs}$$

B_i the predicted biomass of the catch in year i is calculated as $\sum_{js} C_{ijs} w_{jsr}$

M_{js} is the instantaneous natural mortality rate for fish of age j and sex s.

<u>Fundamental model parameters</u>

q is the catchability

s_{js} is the gear selectivity for fish of sex s and age j

n_i is the number of fish in age-class 1 recruiting in year i for both sexes

m_j is the number of female fish in age-class j in year 1

ε is the deviation from the effort-fishing mortality relationship in year i

a is a parameter determining the change in natural mortality for older females.

Data and model inputs

Y is the number of years of being modelled
S_{ijs} is the number of fish in year i which are sex s and aged j
B_i^{obs} is the observed biomass of the catch in year i
E_i is the effort in year i
M is the assumed instantaneous natural mortality rate for males and females <11 y.
w_{jsr} is the average weight for fish of sex s who are age j in each period r.
$p_s, p_c, p_\varepsilon, p_\delta$ are the penalty weights associated with various components of the log-likelihood function

The Catch Equations

To model the fishing process we use the standard catch equations which assume that fishing and natural mortality are continuous processes throughout the year. That is,

$$C_{ijs} = \frac{F_{ijs}}{F_{ijs} + M_{js}} N_{ij}\left(1 - \exp(-F_{ijs} - M_{js})\right),$$

and

$$N_{i+1,j+1,s} = \exp\left(-F_{ijs} - M_{js}\right)N_{ijs}.$$

The last age class, k, is a "plus" age-group which accumulates all fish aged k and older, so for $j+1=k$ the previous equation is replaced by

$$N_{i+1,k,s} = \exp\left(-F_{i,k-1,s} - M_{ks-1}\right)N_{i,k-1,s} + \exp\left(-F_{iks} - M_{ks}\right)N_{iks}.$$

Model structure to define fundamental parameters

To restrict the number of parameters related to fishing mortality that need to be estimated, we employ the "separable" assumption. That is, the fishing mortality rates are comprised of an age/ sex specific selectivity component and a fishing intensity component which is proportional to fishing effort.

$$F_{ijs} = s_{js}\ q\ E_i\ \varepsilon_i$$

At least one of the s_{js} is fixed at a value of 1, and the model is structured such that a range of age-classes can be specified for either one or both sexes where the s_{js} are fixed at 1.

M was constant for all males and the younger females. For older females, M was allowed to increase linearly to the accumulator age, such that

$$M_{j2} = M \qquad 6 \leq j \leq k$$

$$M_{j1} = M \qquad 6 \leq j \leq 10$$

$$M_{j1} = M + a(j-5) \qquad 6 \leq j \leq k$$

The unequal sex ratio observed in the catch for most years leads to a number of alternative assumptions regarding the underlying sex ratio in the population. We have attempted to model the sex-specific nature of the fisheries data with fairly simple assumptions. We assume that for the first age-class recruiting to the fishery the sex ratio is equal. Thus,

$$N_{i11} = N_{i12} = n_i . \qquad i \leq Y - 2$$

$$N_{i11} = N_{i12} = \exp[(\sum_{i=1}^{Y-2} \log(n_i)) / (Y-2)]$$

We looked at a number of ways to estimate the initial (i.e. first year) numbers-at-age for age-classes 2 to k. We have chosen to estimate age-specific cohort-size parameters for females and calculate the number of males based on the assumption that fishing mortality rates were constant prior to the first year. That is,

$$N_{1j1} = m_j \qquad 2 \leq j \leq k$$

$$N_{1j2} = m_j \frac{\sum_{l=1}^{l<j} \exp(-Z_{l2})}{\sum_{l=1}^{l<j} \exp(-Z_{l1})} \qquad 2 \leq j \leq k$$

where Z_{ls} is the total instantaneous mortality rate for fish of age l and sex s prior to the first year. The Z_{ls} are calculated by estimating an additional parameter for fully-recruited fishing mortality prior to the first year and assuming the same age and sex-specific selectivities as estimated for the years with fisheries data.

Maximum likelihood estimation

The parameters of the model are estimated by maximising the log-likelihood function. The log-likelihood function consists of the sum of several components, the most important of which correspond to the age-composition data.

The log-likelihood function has two components arising from the fit between the observed and the predicted catch and age-composition data. Assuming a multinomial distribution for the observed proportion-at-age data, the log-likelihood component for this data is

$$f_s = \sum_{ijs} S_{ijs} \ln P_{ijs} \sum_{ijs} S_{ijs} \ln\left(\frac{S_{ijs}}{\sum_j S_{ijs}}\right).$$

The second term in this equation is a constant. It is included as a scalar so that if the predicted and observed proportion-at-age data are identical, the value of this component would be zero.

We assume that the error in the catch biomass estimates is log-normal and the log-likelihood component is ,

$$f_c = p_c \sum_i \left(\ln\left(B_i^{obs}\right) - \ln\left(B_i\right)\right)^2.$$

The contribution to the log-likelihood function for deviations from the fishing mortality relationship is:

$$f_\varepsilon = p_\varepsilon \sum_i \left(\ln \varepsilon_i\right)^2$$

The remaining considerations in development of the rockfish catch-age model relate to determining appropriate penalty weight for the various components of the log-likelihood function. To decrease the number of components of concern we make certain assumptions. First, we assume that the catch biomass the catch is known with virtually no error and use a value of 200 for the p_c penalty weight.

Second, we assume that there is virtually no information in the effort data time series and use a value of 0.01 for the p_ε penalty weight. The result of these assumptions is that the value of their log-likelihood components is extremely small.

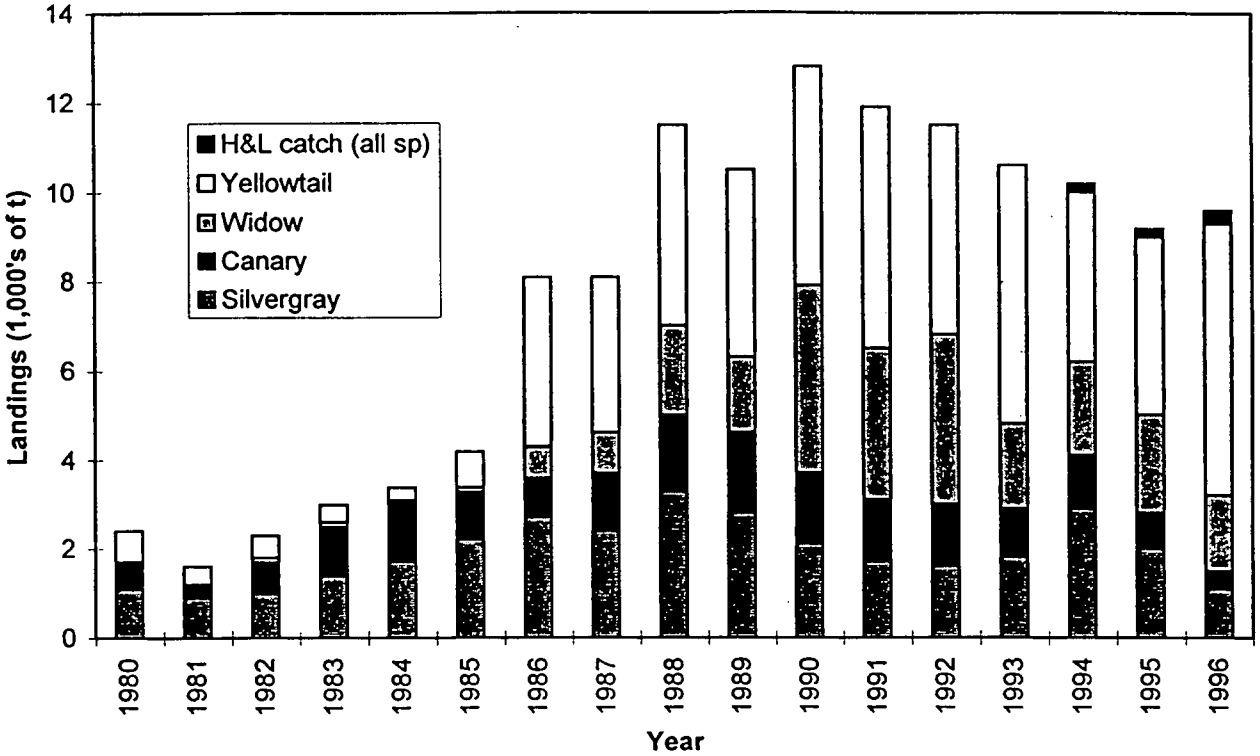


Figure 10.1 Total shelf rockfish landings in B.C waters by species for trawl landings and grouped for hook-and-line(1980-1996)

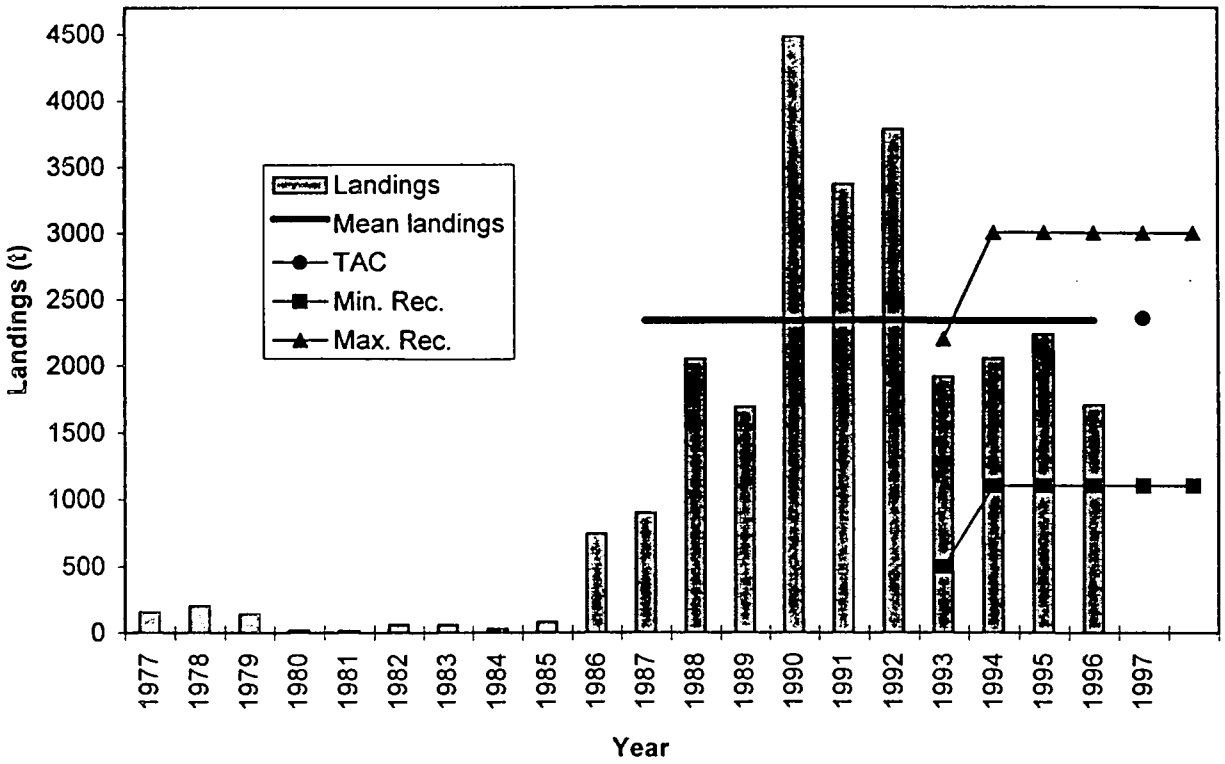


Figure 10.2 Widow rockfish landings in B.C.

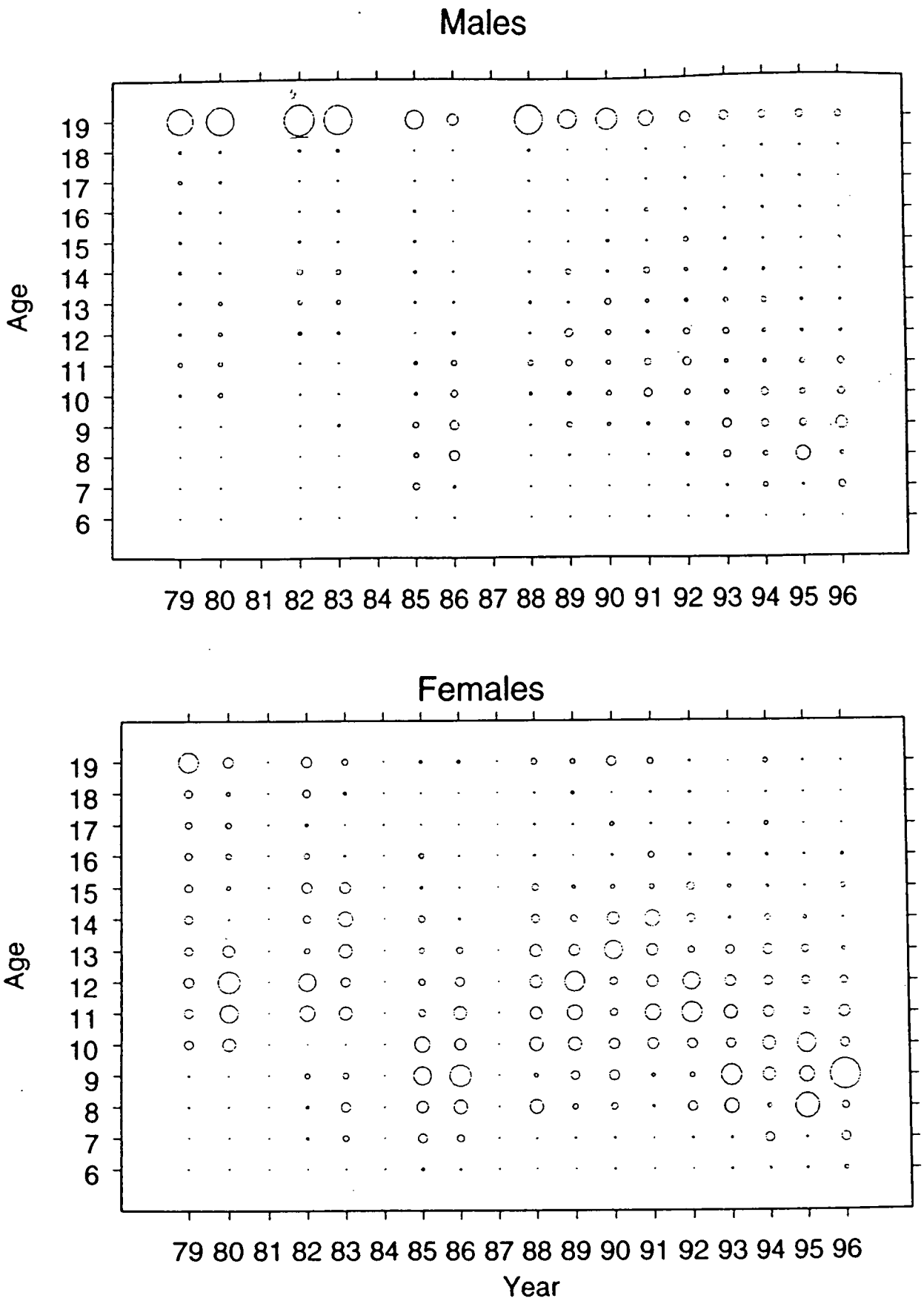
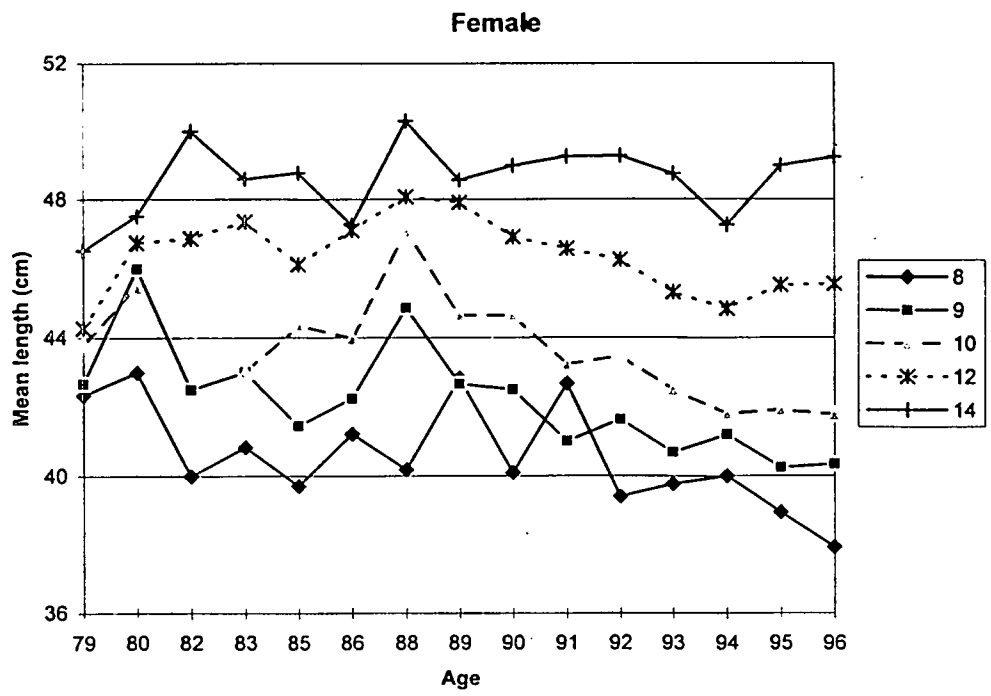
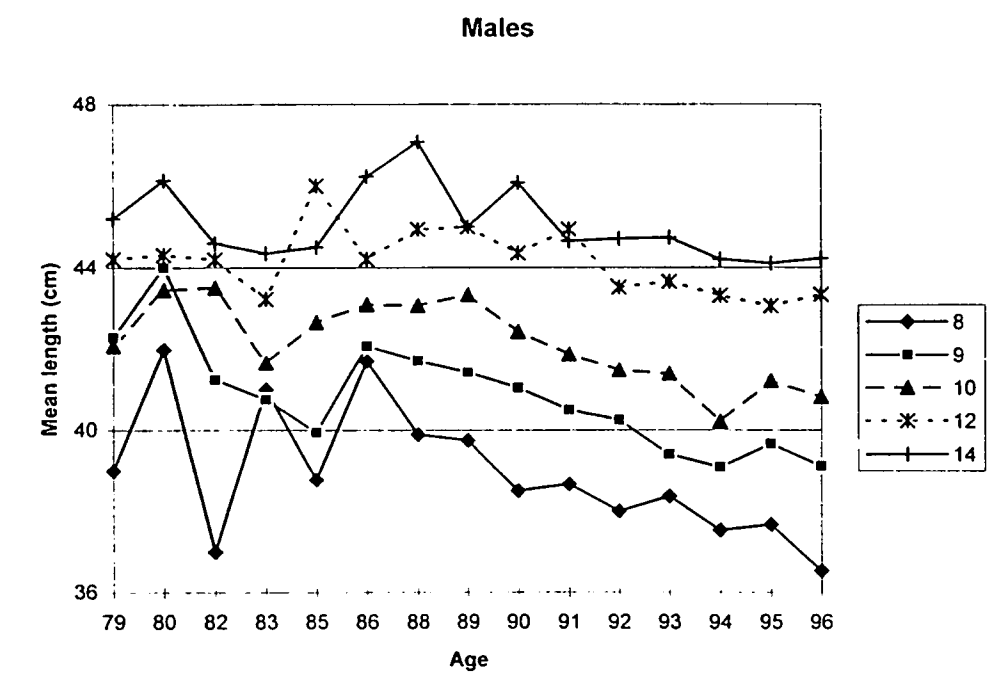


Figure 10.3. Percent age composition for Queen Charlotte Sound yellowtail rockfish. Percent age composition within sex.

Figure 4a and 4b. Queen Charlotte Sound yellowtail rockfish mean size at age for selected ages over time.





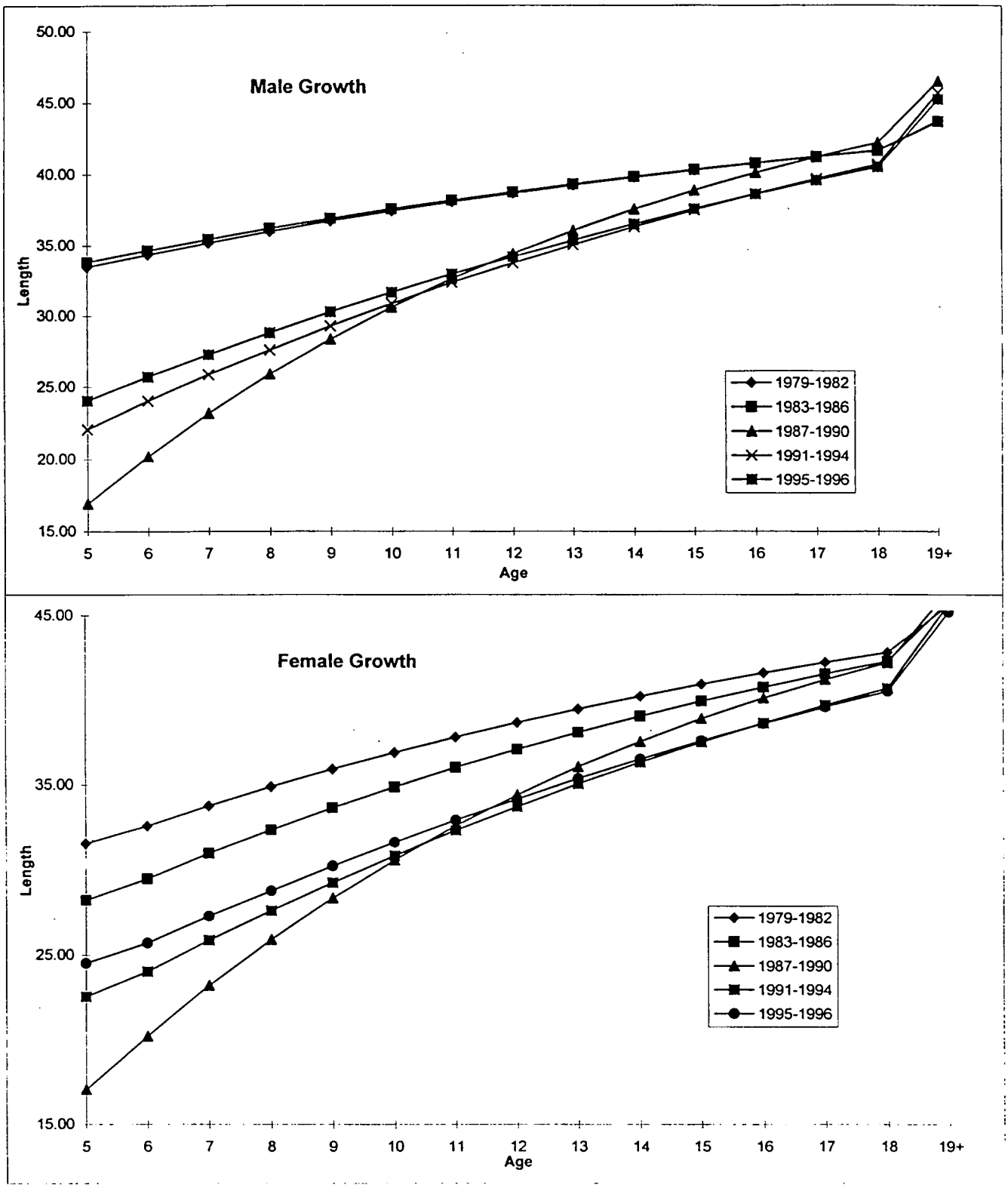


Figure 10.5a and 10.5b. Growth of yellowtail rockfish (Queen Charlotte Sound samples)

Figure 10.6 Composite graphs for initial run of coastal yellowtail rockfish.

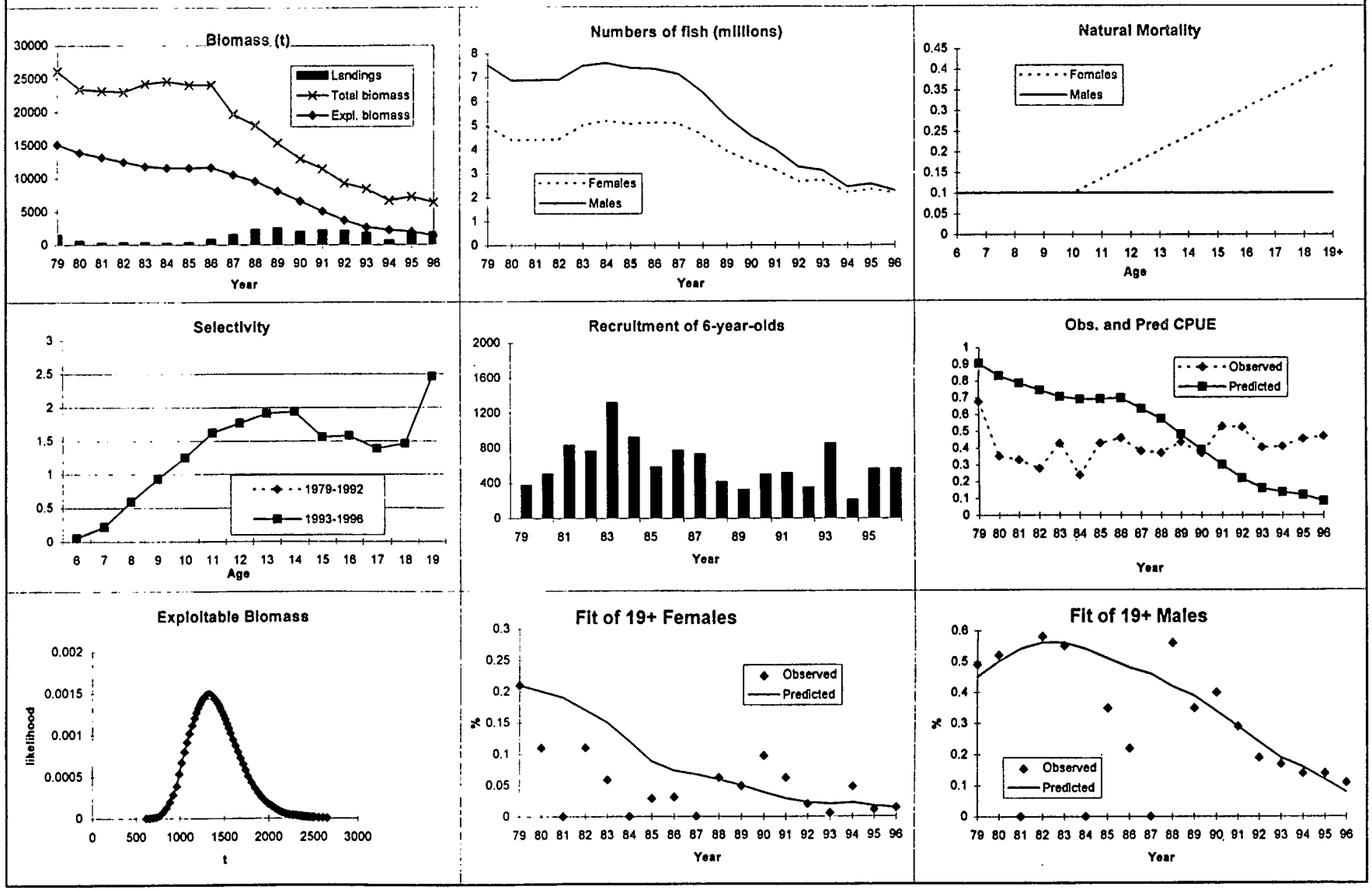


Figure 10.7a Plots of residuals of fit to female age composition residuals for initial run of Queen Charlotte Sound yellowtail rockfish

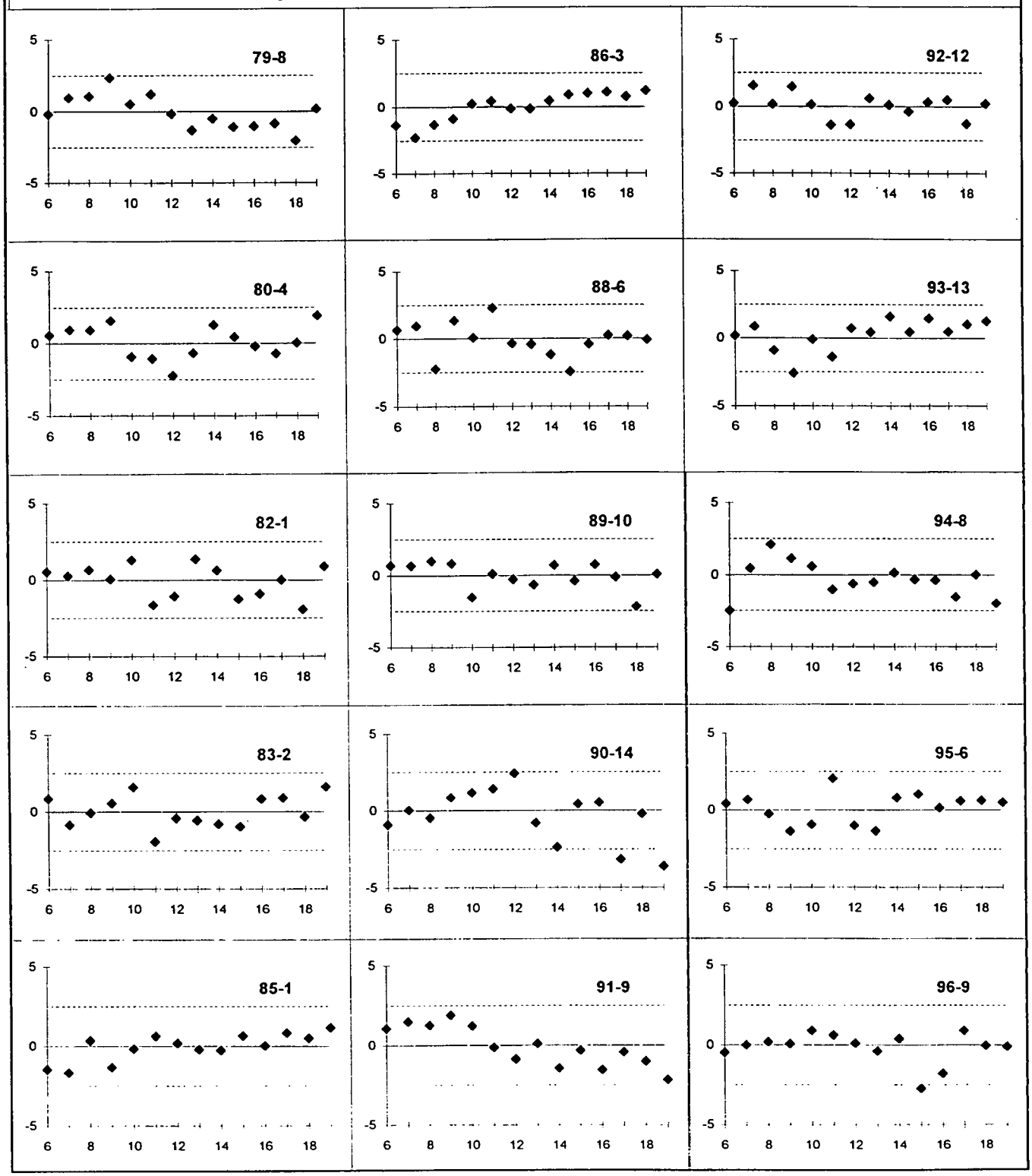
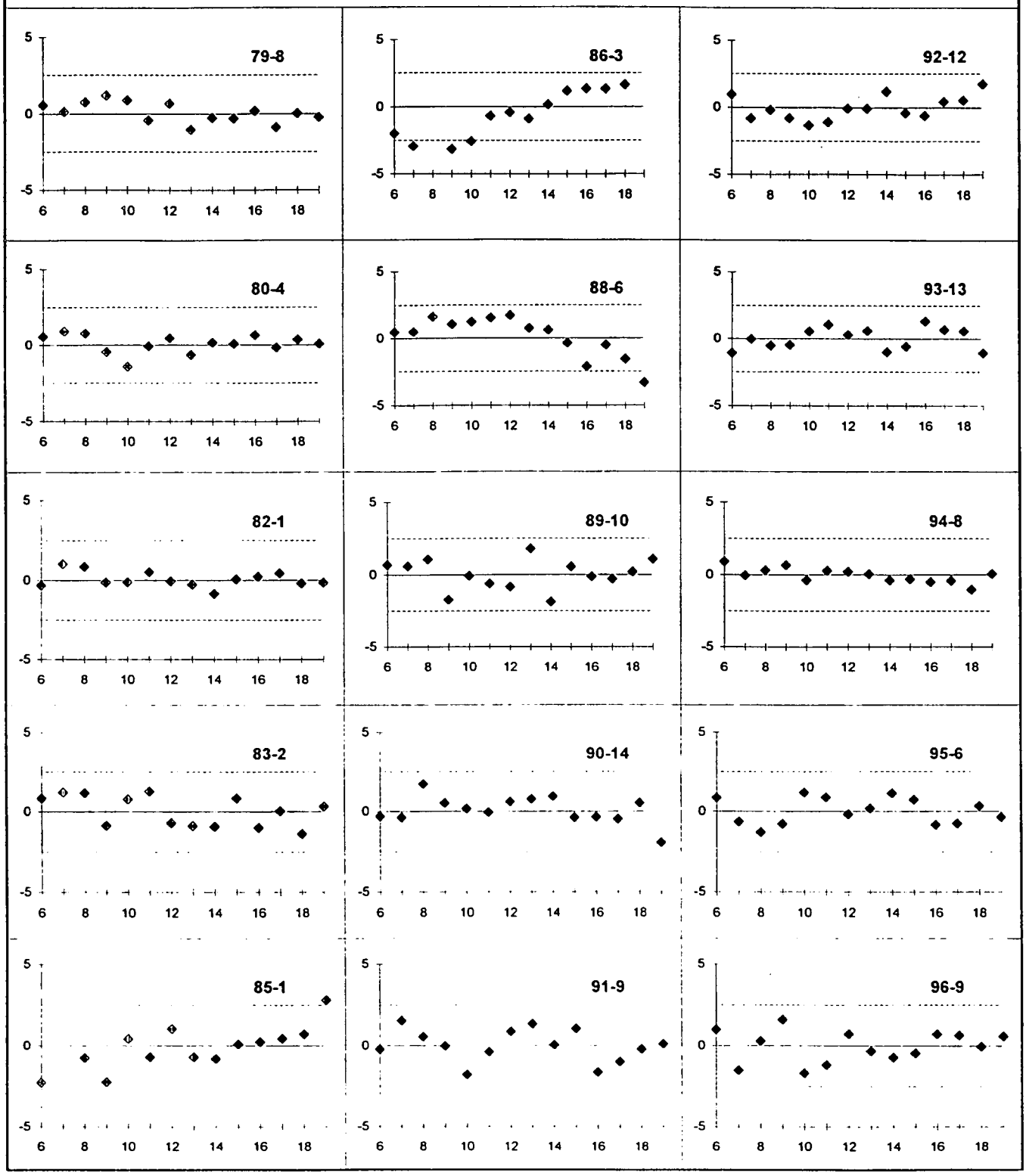


Figure 10.7b Plots of residuals of fit to male age composition for initial run of Queen Charlotte Sound yellowtail rockfish



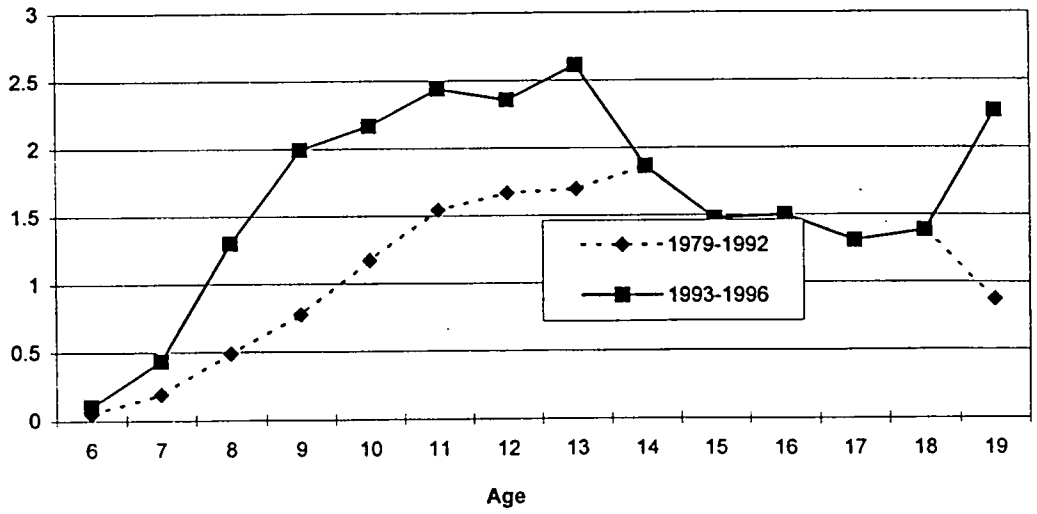


Figure 10.8 Two-period selectivity for Queen Charlotte Sound yellowtail rockfish (lower 19+ value for females, higher value for males).

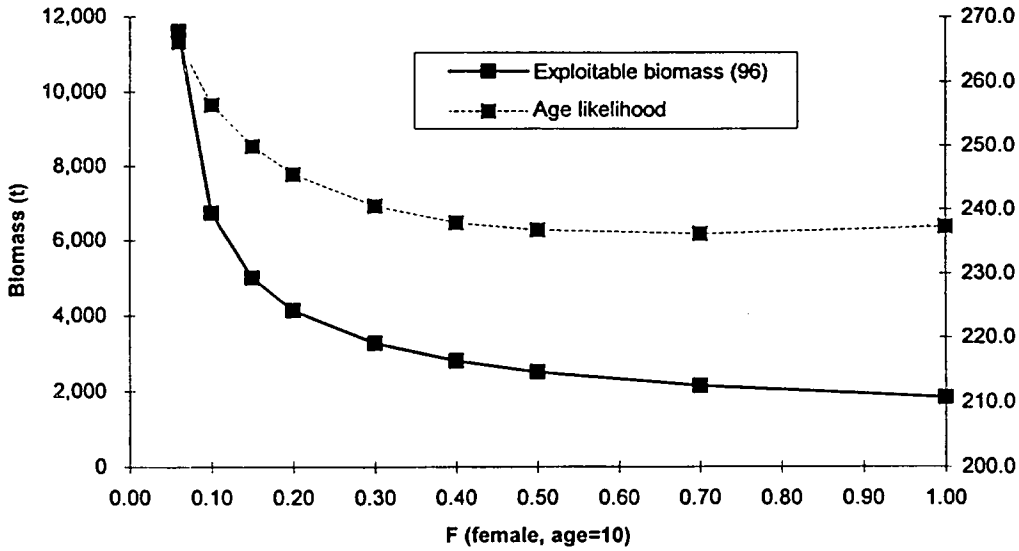


Figure 10.9 Biomass and age likelihood for varying F (two selectivity periods: 79-92, 93-96), Queen Charlotte Sound yellowtail rockfish

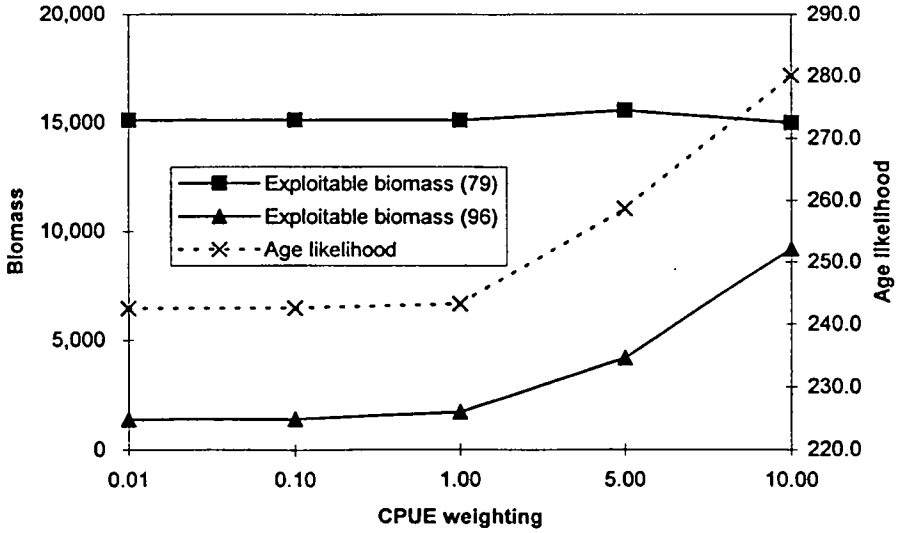


Figure 10.10 Biomass and age likelihood versus CPUE weighting, Queen Charlotte Sound yellowtail rockfish

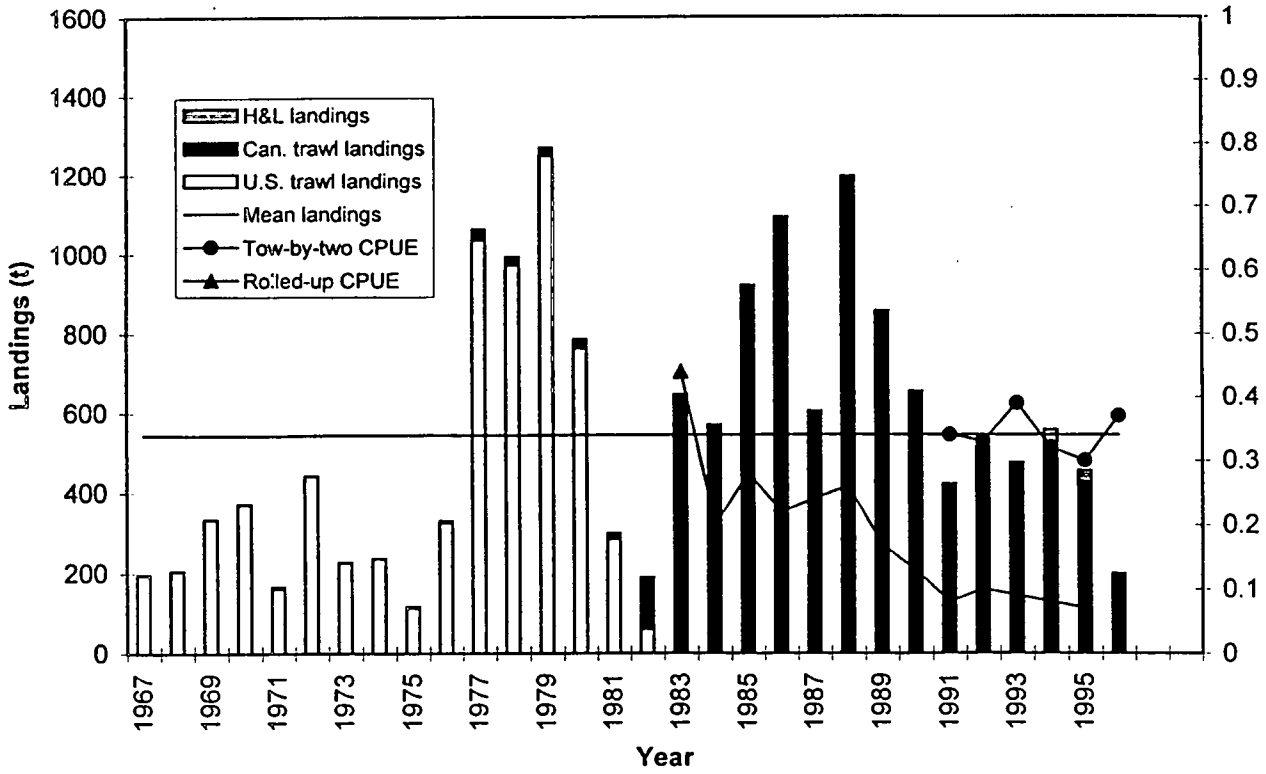


Figure 10.11 Silvergray rockfish landings and bottom trawl CPUE (25% qualified rolled-up and tow-by-tow) for Area 3C+D.

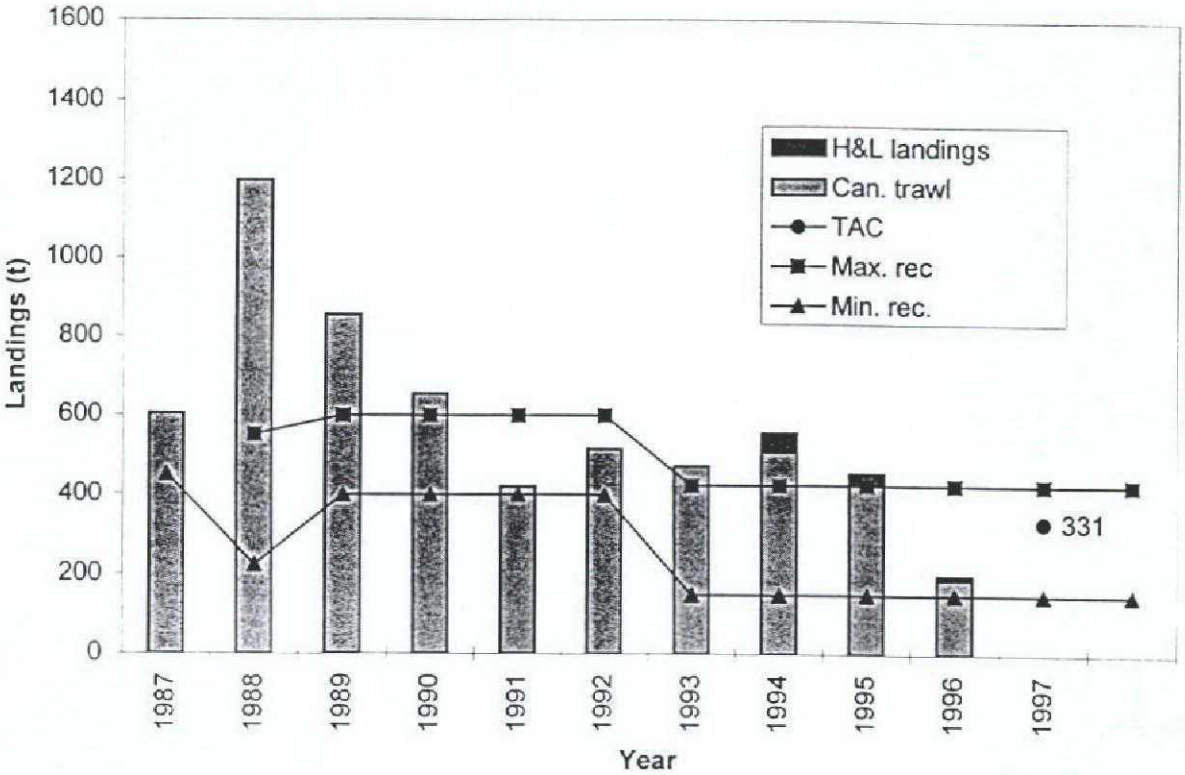


Figure 10.12 Silvergray rockfish landings and recommended yield options for PMFC Area 3C+D.

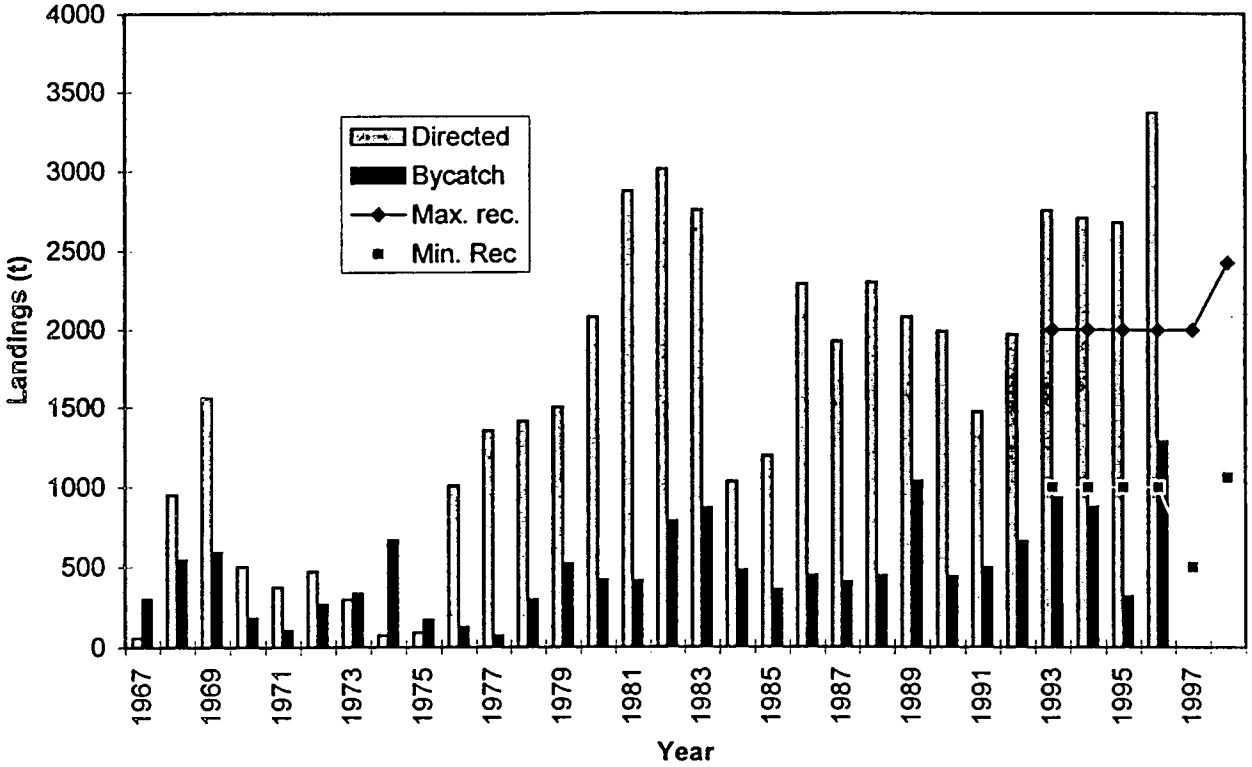


Figure 10.13 Boundary stock total yellowtail rockfish landings and fishery for Areas1+3B+3C.

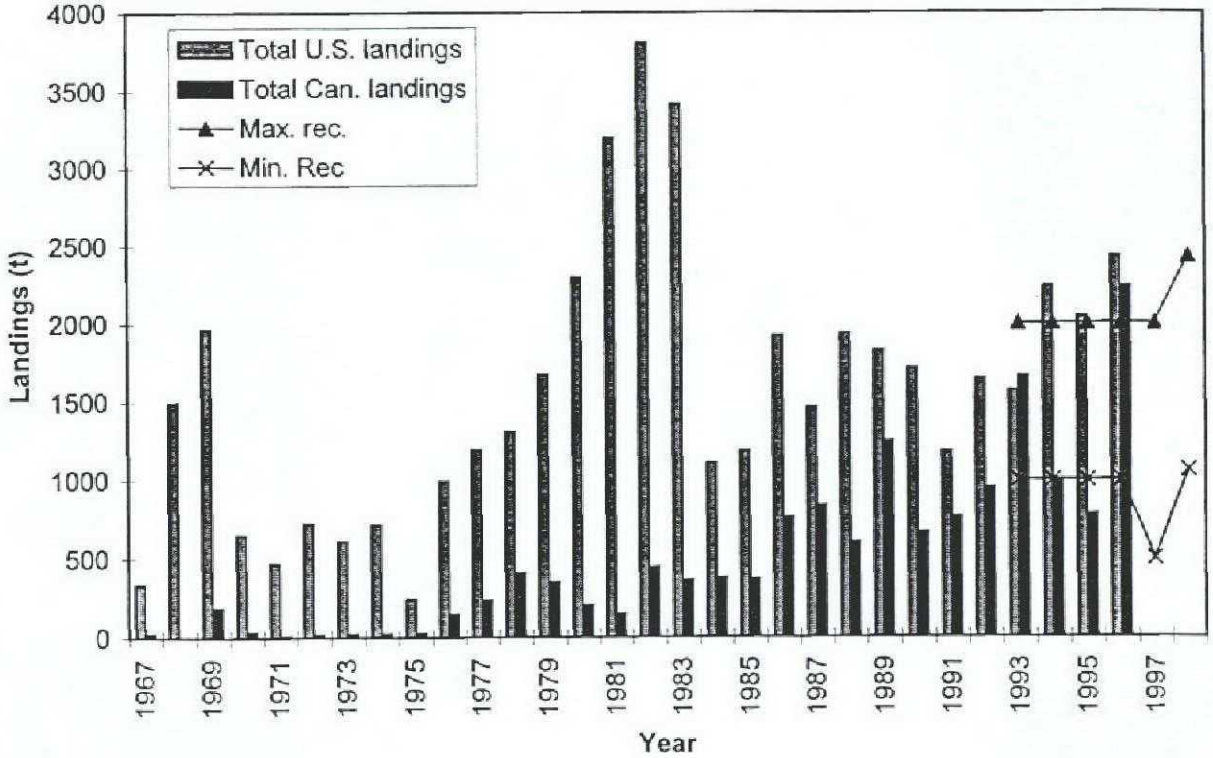


Figure 10.14 Boundary stock total yellowtail rockfish landings by nation Areas 1+3B+3C.

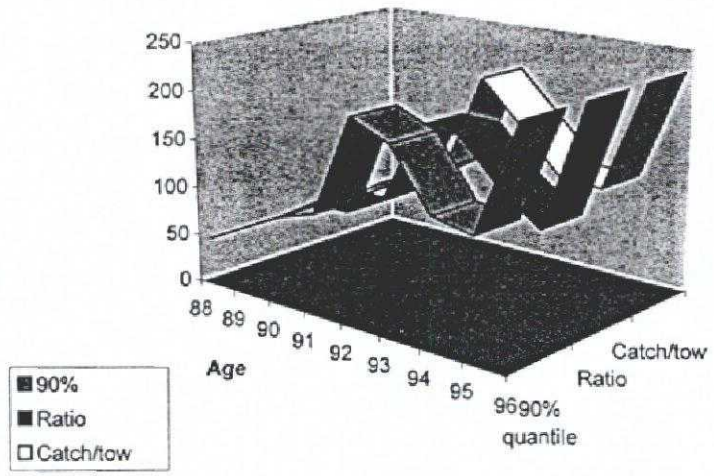


Figure 10. 15 Yellowtail rockfish bycatch index in the Canadian offshore hake fishery

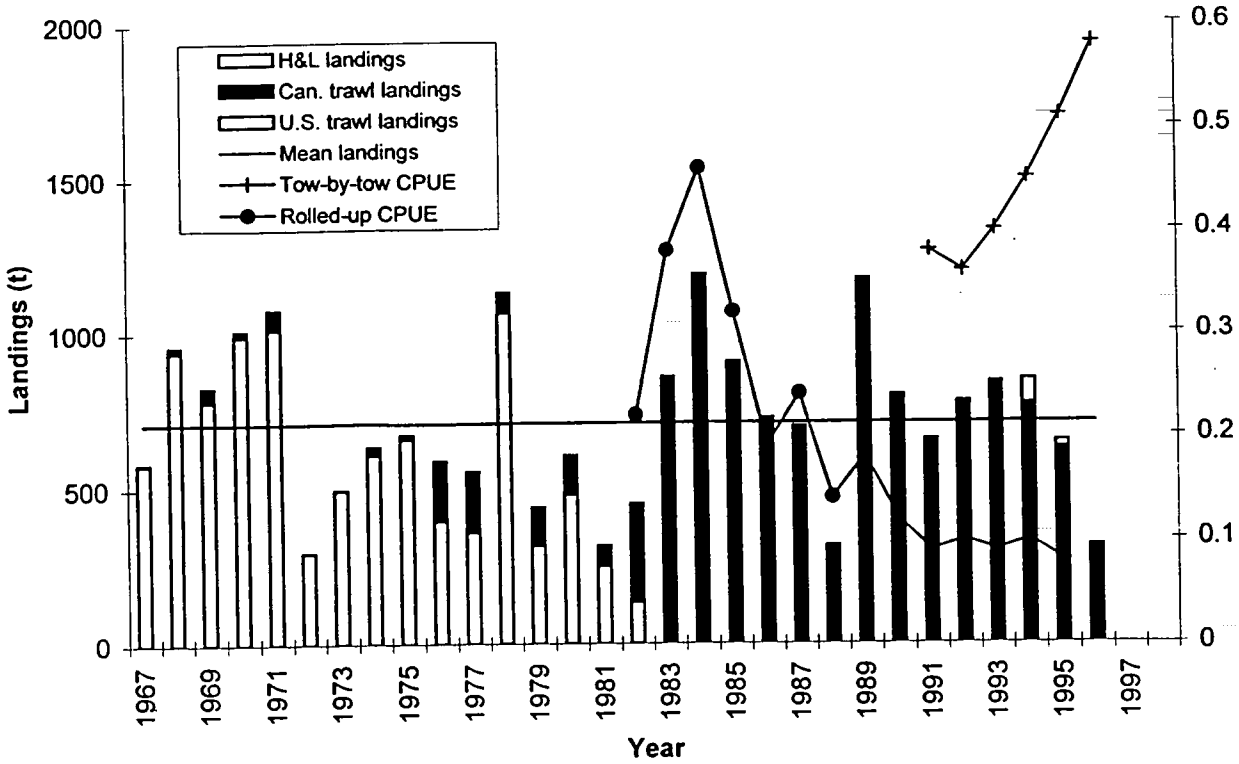


Figure 10.16 Canary rockfish landings and bottom trawl CPUE (rolled-up and tow-by-tow) for Area 3C+3D.

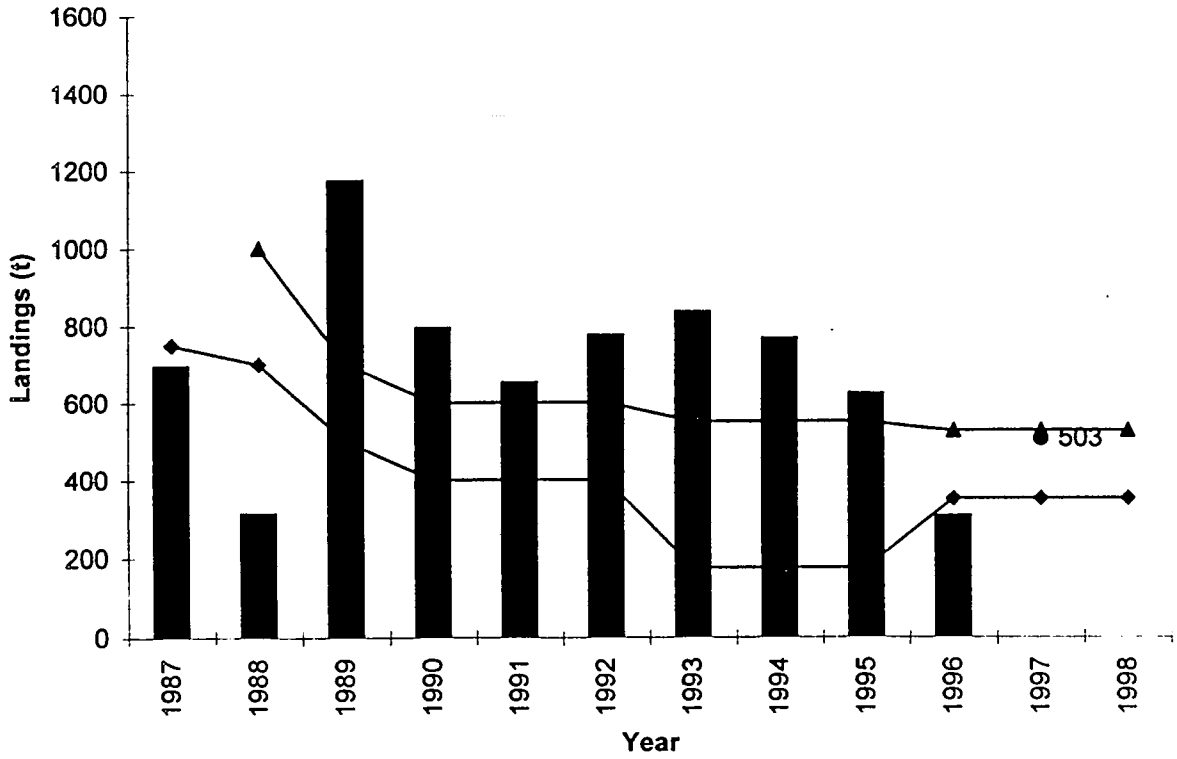


Figure 10.17 Canary rockfish landings, recommended yield options and TAC for PMFC Area 3C+3D.

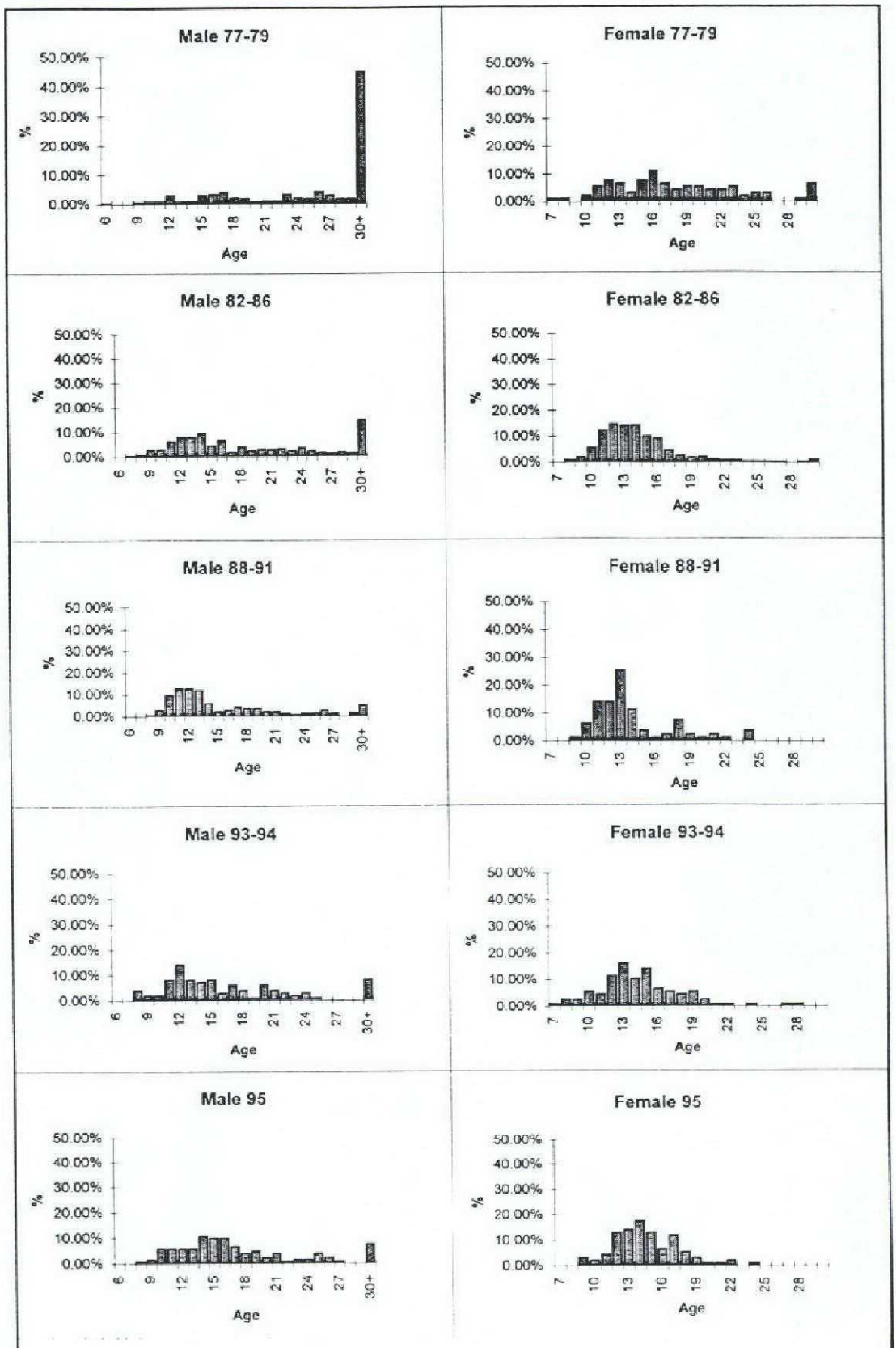


Figure 10.18 Canary rockfish age composition for Areas 3C+3D

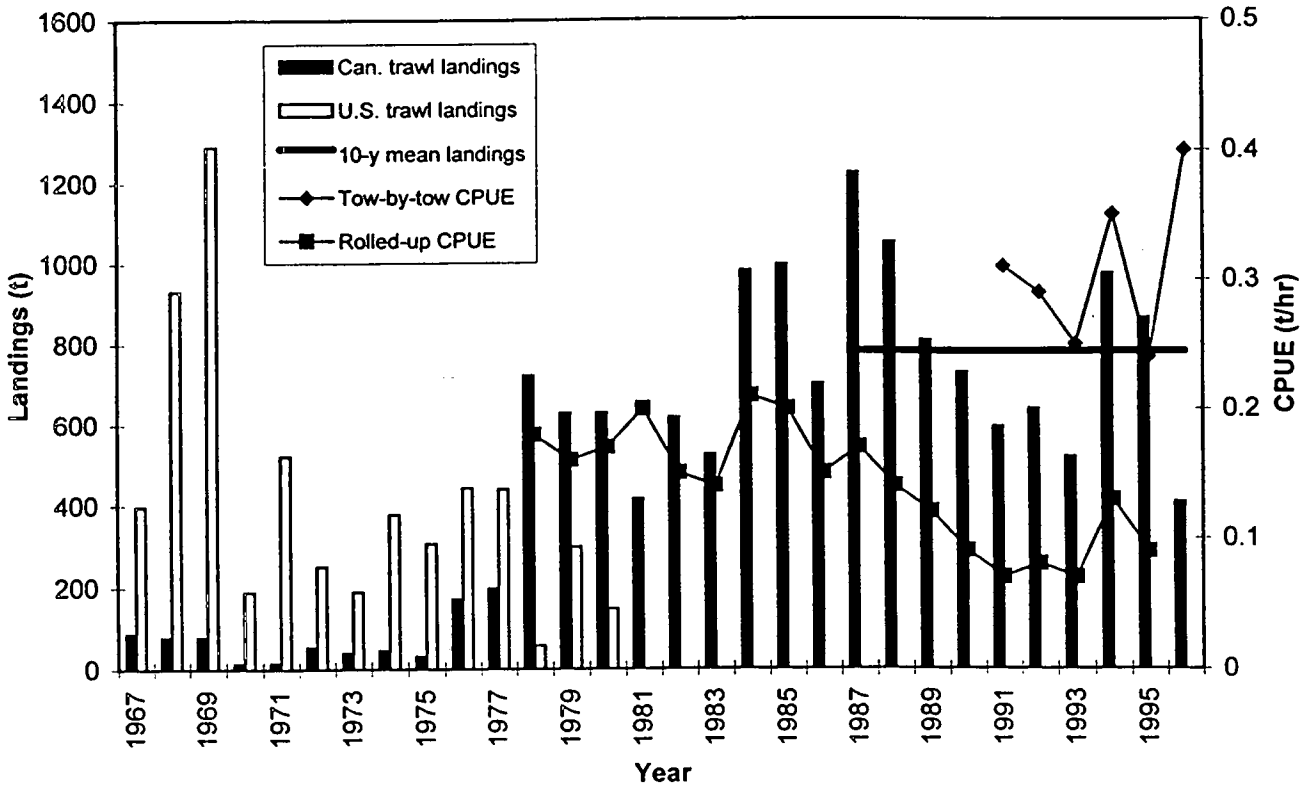


Figure 10.19 Silvergray rockfsh landings and bottom trawl CPUE (25% qualified rolled-up, and tow-by-tow) for Area 5A+5B)

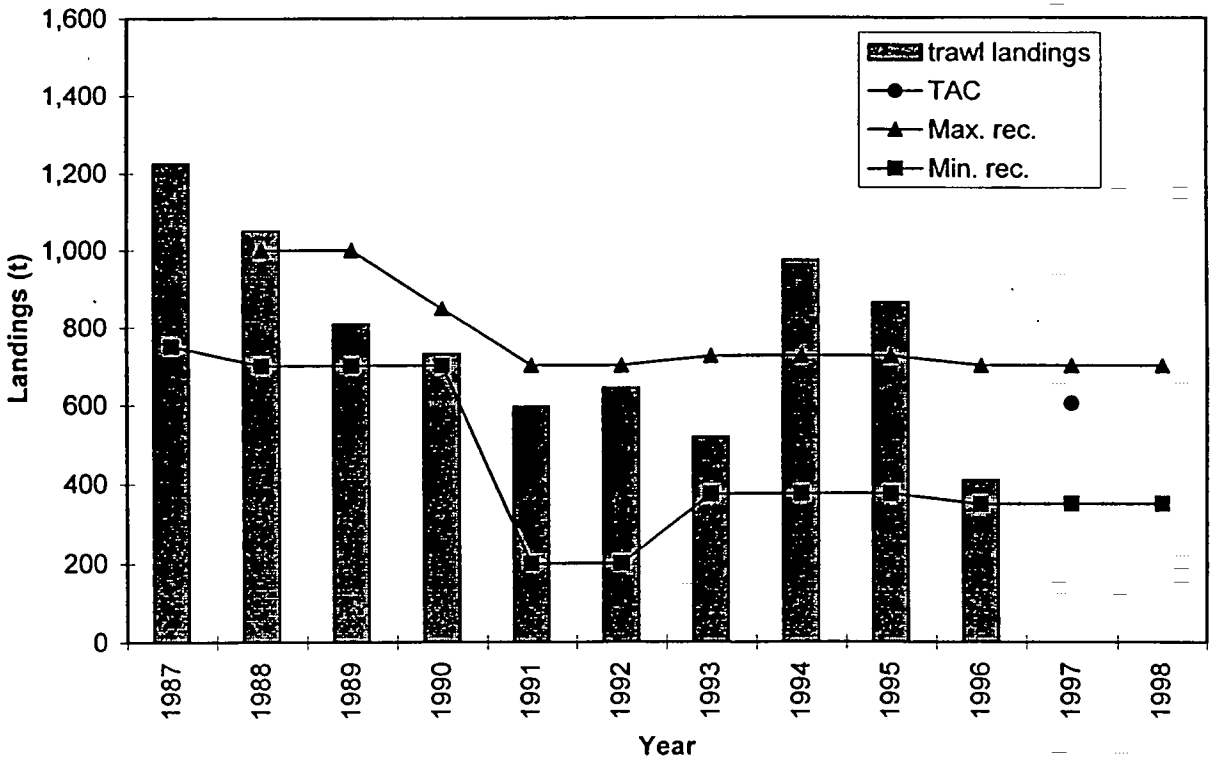


Figure 10.20 Silvergray rockfish landings and recommended yield options for Area 5A+B.

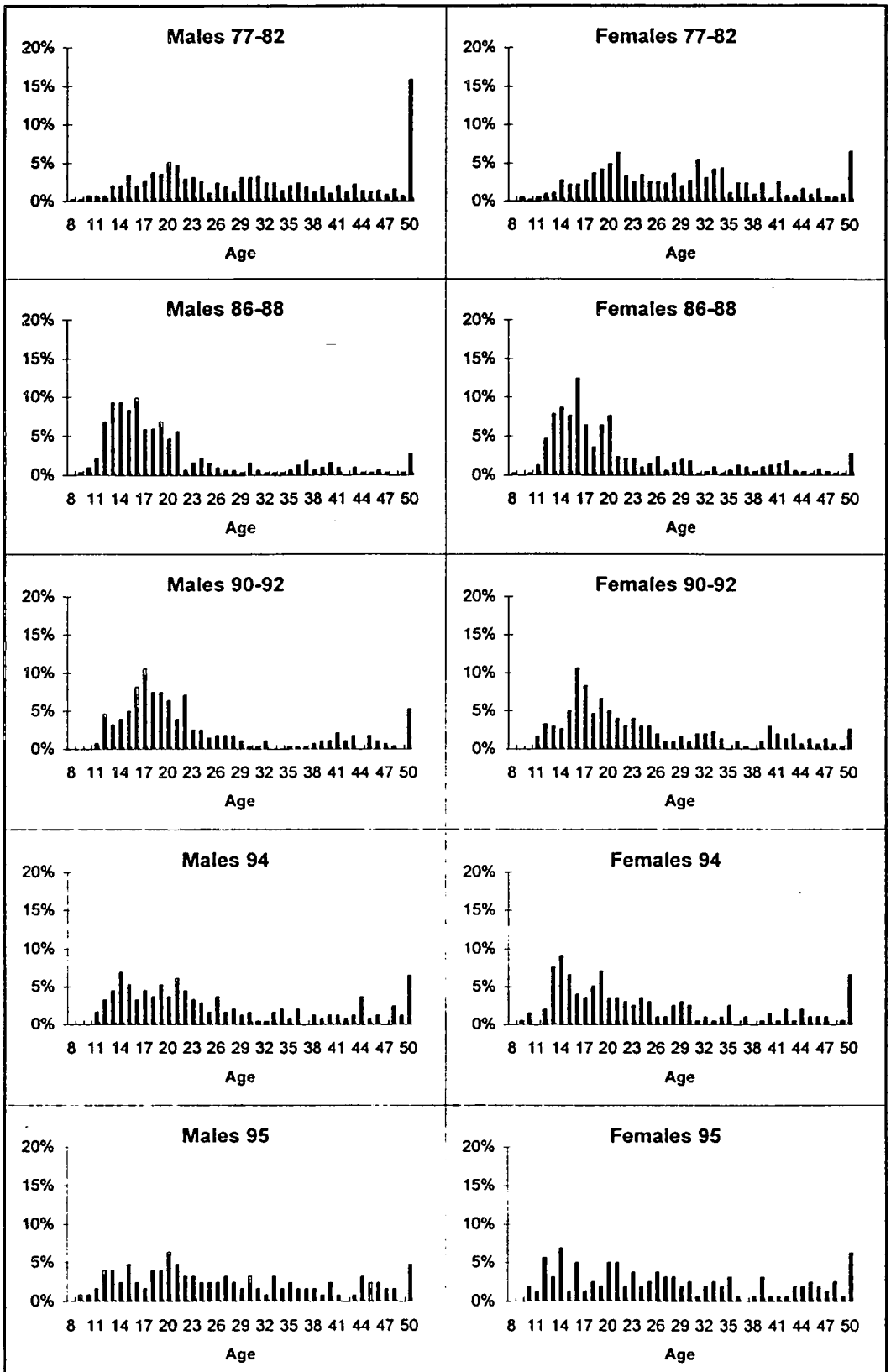


Figure 10.21 Silvergray rockfish age composition for Areas 5A and 5B

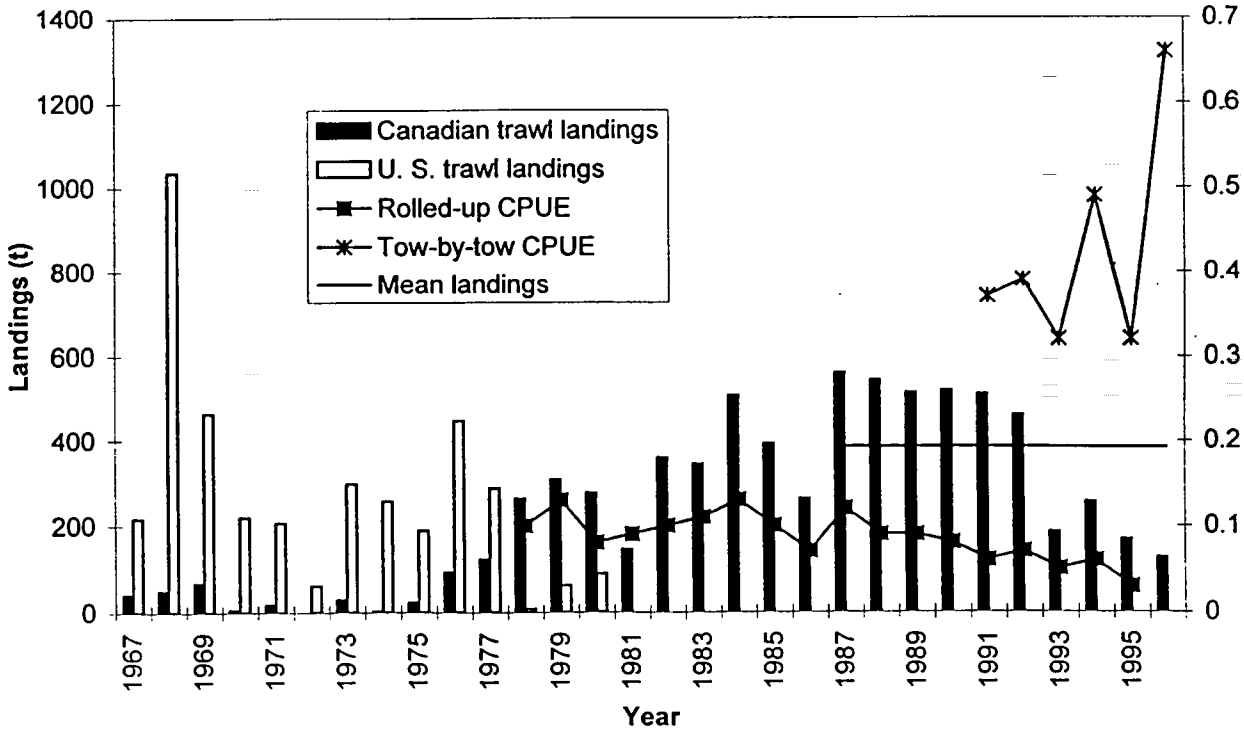


Figure 10.22 Canary rockfish landings and bottom trawl CPUE (25% qualified rolled-up and tow-by-tow) for Areas 5A+5B.

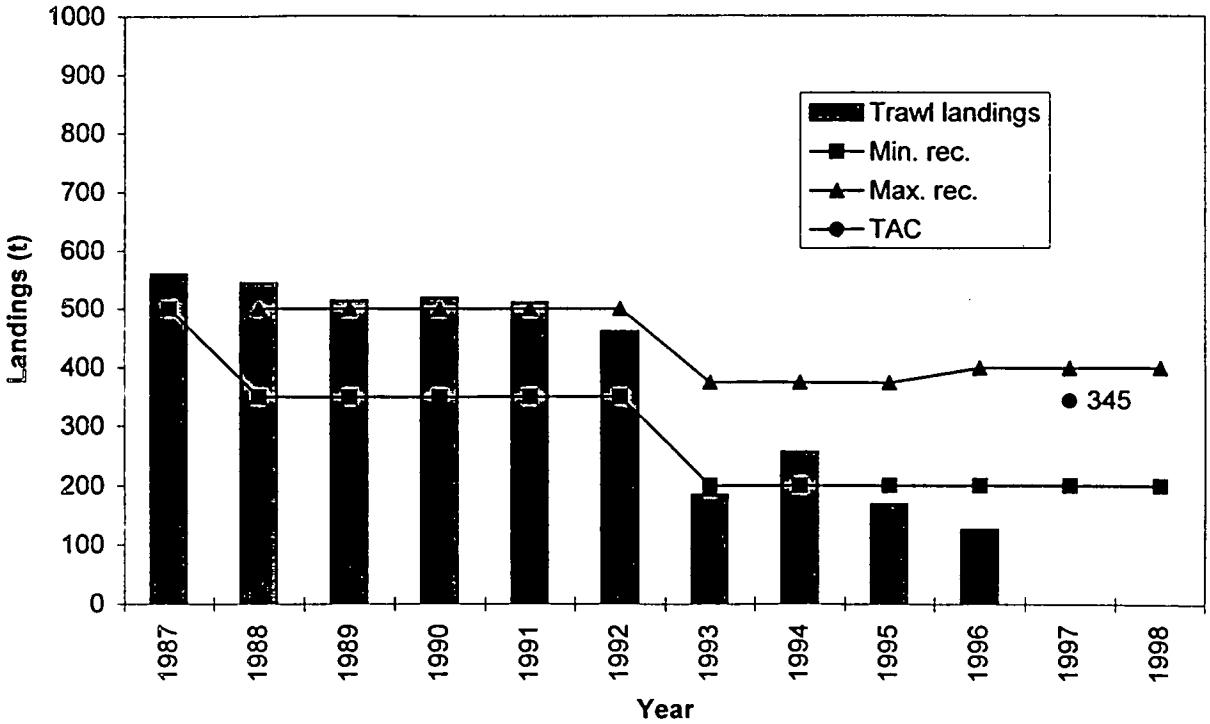


Figure 10.23 Canary rockfish landings and recommended yield options for PMFC Area 5A+5B.

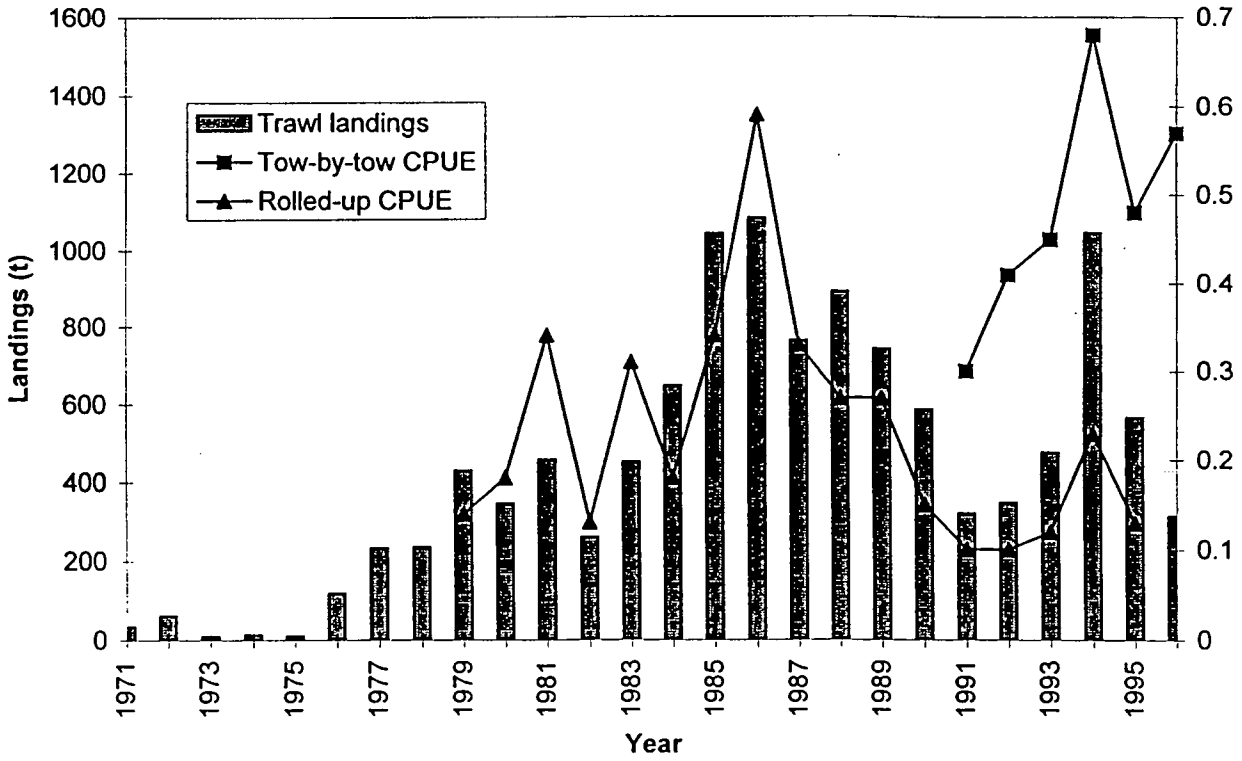


Figure 10.24 Silvergray rockfish landings and CPUE (25% qualified rolled-up and tow-by-tow) for Area 5C+5D.

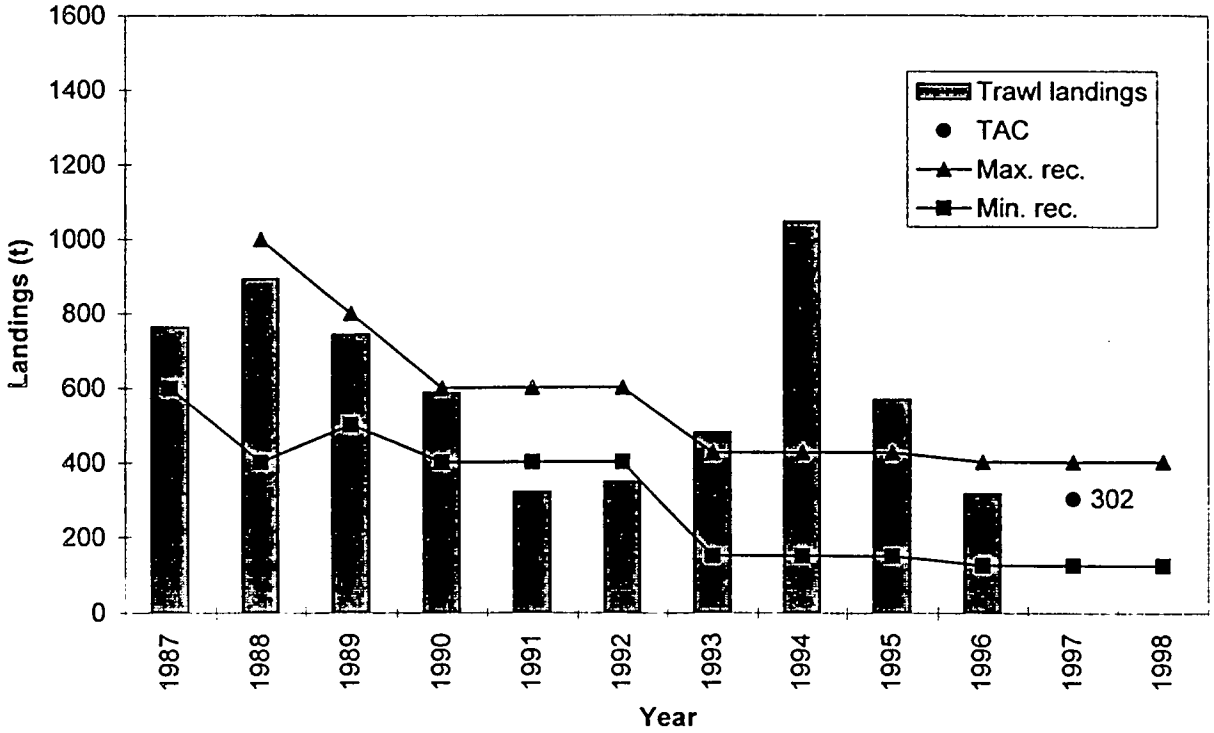


Figure 10.25 Silvergray rockfish landings, recommended yield options and TAC for PMFC Area 5C+5D.

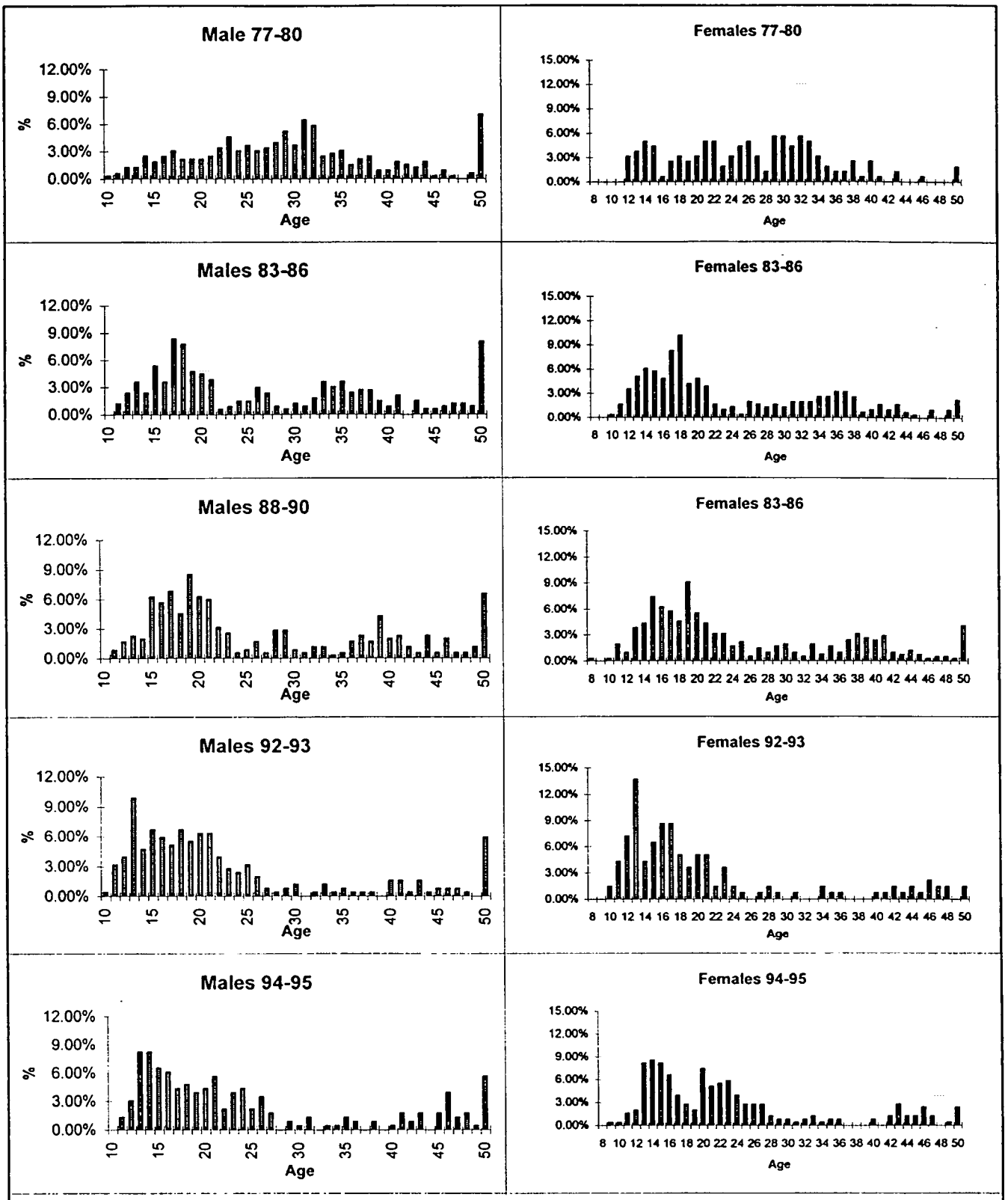


Figure 10. 26 SIlvergray rockfish age composition for Area 5C+5D

Table 10.1 Mean annual landings and recommended yield ranges for the principal stocks of silvergray, widow, yellowtail and canary rockfish in B. C. waters

PMFCAreas	Species	10-year Mean Harvest(t)	1996 Landings (t)	1997 Rec. range (t)	1998/1999 Rec. range (t)
1, 3B-3C[a]	yellowtail	3,015	4,664	500-2,000	1,100-2,400
3D-5E	yellowtail	4,011	4,122	2,750-5,100	2,000-4,025
1,3C-5E	widow	2,438	1,702	1,100-3,000	1,100-3,000
3C+3D	silvergray	585	190	150-425	150-425
3C+3D	canary	718	312	350-525	350-525
5A+5B	silvergray	783	411	350-700	350-700
5A+5B	canary	367	131	200-400	200-400
5C+5D	silvergray	343	609	125-400	125-400
5E	silvergray	278	272	175-300	175-300

[a] *U.S. and Canada combined*

Table 10.2 Hook-and-line landings (t) of shelf rockfish, 1994-1996

Species	Year		Major Area				Total
		4B	3CD	5AB	5CD	5E	
Silvergray	1994	0	48	2	3	51	104
	1995	0	29	3	18	99	149
	1996	1	9	2	28	66	106
	Total	1	86	7	49	216	359
	Mean	0	29	2	16	72	120
Yellowtail	1994	2	1	1	2	1	7
	1995	3	36	0	2	1	42
	1996	4	1	1	1	0	7
	Total	9	38	2	5	2	56
	Mean	3	13	1	2	1	19
Canary	1994	1	78	6	5	19	109
	1995	0	23	3	9	17	52
	1996	0	6	6	28	12	52
	Total	1	107	15	42	48	213
	Mean	0	36	5	14	16	71
Total	1994	3	127	9	10	71	220
	1995	3	88	6	29	117	243
	1996	5	16	9	57	78	165
	Total	11	231	24	96	266	628
	Mean	4	77	8	32	89	209

Table 10.3 Annual landings (t) of widow rockfish in B. C. waters

Year	4B-3C	3D	5A	5B	5C	5D	5E	Total
1973	2	0	0	0	0	0	0	2
1974	2	0	0	3	0	0	0	5
1975	0	0	0	0	0	0	0	0
1976	3	0	0	0	0	0	0	3
1977	52	0	11	76	0	4	12	154
1978	0	2	1	142	0	0	57	202
1979	1	0	0	129	0	0	10	140
1980	0	5	0	10	0	0	5	20
1981	12	0	0	1	0	0	4	16
1982	0	2	0	6	0	3	51	63
1983	12	3	9	6	1	0	29	60
1984	4	5	0	18	0	0	4	32
1985	0	19	3	13	14	7	25	80
1986	41	607	21	18	6	0	51	744
1987	11	607	86	119	19	0	54	897
1988	27	626	48	1,287	8	24	27	2,047
1989	98	293	53	1,176	57	0	9	1,686
1990	52	1,759	1,196	1,292	60	58	58	4,476
1991	446	1,614	526	652	15	48	64	3,364
1992	373	909	1,995	374	11	38	79	3,779
1993	120	750	603	356	3	41	42	1,914
1994	23	441	1,574	28	22	2	12	2,101
1995	88	946	1033	318	13	11	7	2,416
1996	267	755	430	229	2	1	18	1,702
Total	25,903							
Mean	1,850							
Last 10y	2,438							
Last 5y	2,382							

Table 10.4. Number of samples and number of aged widow rockfish

Year	3CD		5AB		5CD		5E		Grand Total	
	Samples	Aged fish	Samples	Aged fish	Samples	Aged fish	Samples	Aged fish	Samples	Aged fish
1979	0	0	1	100	0	0	1	99	2	199
1988	0	0	1	200	0	0	0	0	1	200
1989	2	54	11	258	1	24	0	0	14	336
1990	5	151	9	252	0	0	0	0	14	403
1992	1	50	10	317	1	30	0	0	13	434
1993	3	151	7	237	0	0	0	0	10	388
1994	1	45	6	228	1	60	0	0	8	333
1995	6	217	6	231	0	0	0	0	12	448
Grand Total	18	668	51	1823	3	114	1	99	74	2741

Table 10.5 Annual trawl landings (t) of yellowtail rockfish from B. C. waters

Year	4B and 3C-Can				Area 3D				5A and 5B[a]			5C-5E		Unknown	Total
	U.S. (BT)	Can. (BT)	Can. (MW)	JV hake (MW	Can. (BT)	Can. (MW)	U.S. (BT)	Pol/JV hake (MW)	Can (BT)	Can. (MW)	U.S. (BT	Can. (BT	Can. (MW)		
1967	23	1			2		80		19	0	996	1			1,122
1968	0	0			0		23		23	0	278	0			324
1969	144	43			1		90		86	0	2,174	15			2,553
1970	19	18			1		135		160	14	2,629	17			2,993
1971	1	10			5		127		225	0	1,955	51			2,374
1972	5	11			0		71		692	3	2,735	29			3,546
1973	0	22			0		23		516	5	2,735	1			3,302
1974	8	17			0		109		150	14	809	47	1		1,155
1975	16	11			1		73	6,700	317	97	303	57	0		7,575
1976	68	59			26		4	2,339	590	38	363	164	31		3,682
1977	126	69	5		8		174		762	251	1,242	301	2		2,940
1978	169	58	0	120	24	13	0		1,445	201	397	273	111		2,811
1979	24	57	65	187	8	0	108		1,312	23	192	469	122		2,567
1980	1	48	1	142	12	8	44		471	0	81	124	42		972
1981	0	25	0	120	17	0	10		281	0	0	86	12		555
1982		121	1	320	13	0			280	13		87	12		847
1983		8	9	347	36	0			308	15		58	14		795
1984		23	0	350	19	0			177	18		86	30		703
1985		65	38	264	288	0			341	0		80	129		1,205
1986		238	212	311	941	2,142			822	0		92	12		4,770
1987		197	308	330	835	1,143			1,431	101		150	1		4,496
1988		226	41	334	954	1,083			1,307	986		127	22		5,100
1989		162	98	985	472	798			1,454	1,058		247	7		5,281
1990		215	49	398	735	1,153			1,143	864		521	360		5,438
1991		293	57	414	983	1,061			1,895	317		374	15		5,409
1992		388	124	436	836	820			1,418	721		369	36		5,148
1993		717	116	829	836	767			1,493	372		567	111		5,808
1994		173	155	682	321	884		374	437	232		368	145		3,771
1995		287	339	159	349	796			1,170	735		250	152		4,237
1996		370	610	980	123	1895			629	1139		171	149	14	6,080
Totals	604	3,932	2,228	7,708	7,846	12,563	1,071	9,413	21,354	7,217	16,889	5,182	1,516		97,559
Mean		131	111	406	262	661			712	241		173	68		3,252
Last 10 y		303	190	555	644	1,040			1,238	653		314	100		5,077
Last 5 y		387	269	617	493	1,032			1,029	640		345	119		5,009

[a]Excludes Moresby Gully

Table 10.6 Total domestic trawl landings (t) (3D-5E) and CPUE (t/hr) (25% qualified) for bottom trawl for landings in Queen Charlotte Sound (5A+5B) or Area 3D stock of yellowtail rockfish. CPUE is unadjusted for changes in catchability over time.

Year	Total Ldgs (t) (3D-5E)	Qual. Ldgs	Areas 5A+5B (excluding Moresby Gully) Rolled-up CPUE	No. Ldgs	Tow by tow CPUE	Median CPUE	Qual. Ldgs	Area 3D Rolled-up CPUE	# Ldgs.	Tow by tow CPUE
1966	324									
1969	2,366	60								
1970	2,956	135	0.5	24						
1971	2,363	212	0.28	39						
1972	3,530	579	0.45	47						
1973	3,280	491	0.46	50						
1974	1,130	93	0.29	18						
1975	7,548	264	0.28	39						
1976	3,555	392	0.28	49						
1977	2,745	615	0.23	94						
1978	2,464	1,282	0.45	109						
1979	2,234	1,191	0.56	92						
1980	780	387	0.31	64						
1981	410	191	0.31	41						
1982	405	180	0.27	39						
1983	431	188	0.42	31						
1984	330	106	0.24	26						
1985	838	249	0.44	36			240			
1986	4,009	621	0.44	66			441	0.62	41	
1987	3,661	774	0.38	112			405	0.68	35	
1988	4,499	893	0.37	127			701	0.80	64	
1989	4,036	1,201	0.42	150			331	0.55	51	
1990	4,776	668	0.35	139			551	0.44	104	
1991	4,645	1,548	0.41	140	0.38	1024	834	0.63	125	0.61
1992	4,200	1,032	0.39	130	0.33	873	650	0.53	160	0.50
1993	4,146	1,136	0.31	182	0.32	1041	652	0.46	260	0.43
1994	2,247	270	0.37	40	0.17	318	175	0.30	105	0.28
1995	3,782	940	0.41	105	0.29	493	230	0.28	120	0.28
1996[a]	**4,120**	**531**	**n/a**	**n/a**	**0.50**	**165**	**4**	**n/a**	**n/a**	**n/a**
Total	81,810									
Mean	2,821									
Last 10 y	4,011									
Last 5 y	3,699									

Table 10.7 Summary of biological samples for the coastal stock of yellowtail rockfish

Year		Q. C. Sd.			All coastal stock		
	Samples	Number aged	Weighting		Samples	Number aged	Weighting
1975	0	0	0		1	100	100
1976	0	0	0		4	393	200
1977	0	0	0		2	196	141
1978	0	0	0		2	282	141
1979	8	796	283		14	1,389	374
1980	4	399	200		13	1,365	361
1981	0	0	0		0	0	0
1982	1	200	100		2	396	141
1983	2	298	141		3	348	173
1984	0	0	0		0	0	0
1985	1	299	100		2	594	141
1986	3	795	173		7	1,982	265
1987	0	0	0		2	536	141
1988	6	584	245		10	1,428	316
1989	10	250	316		18	576	400
1990	14	436	374		35	1,150	400
1991	9	527	300		17	959	400
1992	12	730	346		17	1,007	400
1993	13	828	361		18	1,107	400
1994	8	448	283		12	652	346
1995	6	538	245		6	538	245
1996	9	512	300		9	512	300

Table 10.8 Sex and year-specific growth parameters for Queen Charlotte Sound yellowtail rockfish

Period	Sex	P1	P2	P3
1979-1982	F	25.410	51.00	0.8627
1979-1982	M	29.310	47.81	0.8684
1983-1986	F	20.620	52.71	0.8646
1983-1986	M	29.920	47.82	0.8733
1987-1990	F	-0.222	51.49	0.7943
1987-1990	M	27.210	48.27	0.8607
1991-1994	F	13.070	56.47	0.8800
1991-1994	M	11.110	48.08	0.8304
1995-1996	F	16.450	56.46	0.8928
1996-1996	M	11.270	47.28	0.8272

Table 10.9 Likelihood and biomass values for varying F of 10-year old females for 1996 Queen Charlotte Sound yellowtail rockfish

F(female, 96,age=10)	t B_{79}	t B_{96}	% decline	Total like.	Age like.
0.05	14,242	11,438	80%	359.7	290.1
0.10	13,486	6,413	48%	322.4	274.4
0.15	13,568	4,591	34%	312.1	264.6
0.20	13,763	3,632	26%	305.2	258.1
0.30	14,178	2,625	19%	299.0	250.3
0.40	14,465	2,093	14%	292.6	246.1
0.50	14,723	1,760	12%	290.3	243.9
0.70	15,119	1,358	9%	289.0	242.5
1.00	15,533	1,035	7%	290.8	244.0

Table 10.10 Likelihood and biomass values for varying M, Queen Charlotte Sound yellowtail rockfish.

M	F(female, 96,age=10)	t B_{79}	t B_{96}	% decline	Total like.	Age like.
0.050	0.850	9,746	1,154	12%	289.2	243.0
0.075	0.770	12,089	1,256	10%	289.1	242.6
0.100	0.700	15,110	1,367	9%	289.0	242.5
0.150	0.560	24,027	1,620	7%	288.8	242.4
0.200	0.441	38,928	1,927	5%	288.9	242.5

Table 10.11 Likelihood and biomass values for varying length of second selectivity period, Queen Charlotte yellowtail rockfish

First period	Second period	F(female, 96,age=10)	t B_{79}	t B_{96}	% decline	Total like.	Age like.
1979-1990	1991-1996	0.76	16,498	1,902	12%	279.0	235.4
1979-1991	1992-1996	0.71	16,738	2,101	13%	270.1	226.6
1979-1992	1993-1996	0.66	17,136	2,363	14%	265.2	220.9
1979-1993	1994-1996	0.65	17,124	2,207	13%	280.3	236.1

Table 10.12 Likelihood and biomass values for varying F of 10-year old females for 1996 with two selectivity periods, Queen Charlotte Sound yellowtail rockfish

F(female, 96,age=10)	t B_{79}	t B_{96}	% decline	Total like.	Age like.
0.06	15,684	11,615	74%	313.1	266.1
0.10	15,341	6,741	44%	301.8	256.3
0.15	15,652	5,012	32%	294.7	249.8
0.20	15,959	4,147	26%	290.0	245.4
0.30	16,401	3,264	20%	284.6	240.4
0.40	16,690	2,797	17%	282.0	237.8
0.50	16,898	2,500	15%	280.8	236.6
0.70	17,182	2,135	12%	280.3	236.1
1.00	17,456	1,838	11%	281.7	237.3

Table 10.13 Area 3C+3D bottom landings (t), effort (hr) and CPUE (t/hr) for silvergray rockfish.

Year	Nat.	Total landings	Interviewed landings landings	effort	Nominal CPUE	Median CPUE		25% Qualified landgins	effort	CPUE	Nominal CPUE	Tow-by tow CPUE
1967	USA	196	195	4,471	0.04			-	-	-		
1968	USA	205	200	2,928	0.07			-	-	-		
1969	USA	334	334	3,647	0.09			-	-	-		
1970	CAN	2	2	119	0.02			1	1	1		
	USA	371	358	4,785	0.07			-	-	-		
1971	CAN	5	5	48	0.10			2	2	1		
	USA	161	161	3,009	0.05			-	-	-		
1972	USA	442	442	2,969	0.15			-	-	-		
1973	USA	227	227	2,619	0.09			-	-	-		
1974	CAN	1	1	12	0.08			-	-	-		
	USA	236	235	2,666	0.09			-	-	-		
1975	CAN	4	4	44	0.09			0	0	-		
	USA	113	113	2,938	0.04			-	-	-		
1976	CAN	5	5	9	0.55			0	0	-		
	USA	326	326	3,945	0.08			-	-	-		
1977	CAN	28	28	516	0.05			17	28	0.61		
	USA	1,035	1,035	5,427	0.19			-	-	-		
1978	CAN	22	22	284	0.08			1	8	0.13		
	USA	972	972	6,244	0.16			-	-	-		
1979	CAN	22	22	131	0.17			13				
	USA	1,248	1,248	4,812	0.26			-	-	-		
1980	CAN	23	23	214	0.11			9	15	0.6		
	USA	764	764	3,848	0.20			-	-	-		
1981	CAN	15	15	77	0.19			9	24	0.38		
	USA	284	284	5,424	0.05			-	-	-		
1982	CAN	129	129	388	0.33			124	126	0.99		
	USA	60	60	11,819	0.01			-	-	-		
1983	CAN	646	646	1,455	0.44			390	837	0.47	0.39	
1984	CAN	570	335	1,644	0.20			237	658	0.36	0.3	
1985	CAN	921	349	1,242	0.28			273	521	0.52	0.45	
1986	CAN	1,093	690	3,135	0.22			474	906	0.52	0.44	
1987	CAN	604	516	2,199	0.24			323	458	0.72	0.54	
1988	CAN	1,197	1,007	3,878	0.26			644	1,217	0.53	0.45	
1989	CAN	857	845	5,001	0.17			540	1,177	0.46	0.39	
1990	CAN	654	607	4,727	0.13			315	928	0.34	0.31	
1991	CAN	421	403	4,870	0.08	120		153	556	0.28	0.25	0.34
1992	CAN	514	506	5,297	0.10	132		223	783	0.28	0.25	0.33
1993	CAN	474	426	4,886	0.09	120		217	731	0.3	0.29	0.39
1994	CAN	509	496	6020	0.08	140		245	948	0.26	0.25	0.32
1995	CAN	426	401	5455	0.07	125		208	819	0.25	0.25	0.30
1996	CAN	190	179	2643	0.07	100		64	173	0.37	n/a	0.37
Total		16,306										
Mean		544										
Last 10 y		585										
Last 5 y		423										

Notes:
U.S. Total Landings equals Washington and Oregon combined.
U.S. Interviewed landings from Washington only (Tagart and Kimura 1982).
Median catch in lbs/tow. 1991-1995 based onfisher logs, 1996 basd on observer logs.

Table 10.14 Number of samples and number of aged silvergray rockfish by area

	3CD		5AB		5CD		5E		
year	Samples	Aged fish	Samples	Aged fish	Samples	Aged fish	Samples	Aged fish	Grand Tota
1977	0	0	2	166	3	259	0	0	5
1978	1	99	3	295	3	286	0	0	7
1979	0	0	4	365	1	99	0	0	5
1980	0	0	2	198	2	200	0	0	4
1981	0	0	6	220	0	0	0	0	6
1982	1	199	1	25	0	0	0	0	2
1983	0	0	1	25	1	25	1	25	3
1985	15	875	0	0	2	339	0	0	17
1986	8	623	4	102	2	288	0	0	14
1988	0	0	11	869	2	532	0	0	13
1989	0	0	0	0	3	75	1	25	4
1990	0	0	6	192	10	342	3	77	19
1991	2	102	4	220	0	0	0	0	6
1992	0	0	4	223	4	249	0	0	8
1993	0	0	0	0	7	410	0	0	7
1994	1	48	8	444	11	629	3	191	23
1995	0	0	5	286	6	353	4	269	15
Total	28	1946	61	3630	57	4086	12	587	158

Table 10.15 Estimated yellowtail rockfish landings (t) by trawl fishery from PMFC Areas 1, 3C, and 3B (1967-1996)

		Domest. trawl		Shrimp trawl		Hake Fishery		Total landings		Total	%Can
Year	US	US discard	Can	US	Can	US	Can	US	Can		
1967	35	0	25	0	0	302	0	337	25	362	6.9%
1968	952	0	0	0	0	544	0	1,496	0	1,496	0.0%
1969	1,373	0	187	4	0	587	0	1,964	187	2,151	8.7%
1970	465	0	37	0	0	185	0	650	37	687	5.4%
1971	365	0	11	0	0	107	0	472	11	483	2.3%
1972	457	0	16	0	0	268	0	725	16	741	2.2%
1973	276	0	22	5	0	332	0	613	22	635	3.5%
1974	50	0	25	37	0	629	0	716	25	741	3.4%
1975	66	0	27	38	0	135	0	239	27	266	10.2%
1976	883	0	127	55	17	55	0	993	144	1,137	12.7%
1977	1,155	0	200	40	34	0	0	1,195	234	1,429	16.4%
1978	1,212	0	202	95	84	0	120	1,307	406	1,713	23.7%
1979	1,357	0	146	317	16	0	187	1,674	349	2,023	17.3%
1980	2,028	0	50	230	10	38	142	2,296	202	2,498	8.1%
1981	2,847	0	25	237	1	57	120	3,141	146	3,287	4.4%
1982	2,887	0	122	85	1	381	320	3,353	443	3,796	11.7%
1983	2,736	0	17	256	0	268	347	3,260	364	3,624	10.0%
1984	1,013	0	23	60	0	70	350	1,143	373	1,516	24.6%
1985	942	180	103	46	0	49	264	1,217	367	1,584	23.2%
1986	1,544	294	450	43	0	95	311	1,976	761	2,737	27.8%
1987	1,193	227	505	17	0	61	330	1,498	835	2,333	35.8%
1988	1,705	325	267	16	0	97	334	2,143	601	2,744	21.9%
1989	1,527	291	260	5	0	49	985	1,872	1,245	3,117	39.9%
1990	1,447	276	264	3	0	39	398	1,765	662	2,427	27.3%
1991	945	180	350	42	0	43	414	1,210	764	1,974	38.7%
1992	1,223	233	512	15	0	209	436	1,680	948	2,628	36.1%
1993	1,612	307	833	93	0	14	829	2,026	1,662	3,688	45.1%
1994	2,003	381	321	18	0	178	682	2,580	1,003	3,583	28.0%
1995	1,757	335	586	25	0	137	159	2,254	745	2,999	24.8%
1996	1,777	339	1,254	61	0	248	980	2,425	2,234	4,659	48.0%
Total	37,832	3,368	6,967	1,843	163	5,177	7,708	48,220	14,838	63,058	30.8%
Mean	1,261	112	232	61	5	173	257	1,607	495	2,102	30.8%
Last 10 y	1,674	289	515	30	0	108	555	1,945	1,070	3,015	55.0%
Last 5 y	1,555	296	516	31	0	113	580	1,995	1,096	3,091	54.9%

Note: US estimated discards in the US domestic fishery as 16% annually from 1985 to present

Table 10.16 Comparison among models and areas for 1997 stock size, biomass ratio (1997 estimate relative to 1967), fit to fishery age composition information, and CV of current stock size (*from Tagart et al 1997*).

Stock size (total biomass)

Models	EurS	ColN	VanS	ColVan	Coastwide
1	12,692	33,133	28,060	59,985	44,231
3	6,598	23,519	16,778	32,941	27,784
6	2,155	13,927	22,908	31,226	85,263
8	2,874	22,741	28,780	43,352	56,736

Biomass ration (1997/1967)

Models	EurS	ColN	VanS	ColVan	CoastWide
1	50.2%	59.9%	56.6%	44.5%	32.7%
3	28.3%	43.3%	35.3%	31.7%	21.1%
6	11.0%	26.0%	47.9%	30.2%	63.2%
8	12.5%	41.7%	59.2%	41.4%	42.5%

Fit to fishery age composition (-InL)

Models	EurS	ColN	VanS	ColVan	Coastwide
1	60.39	21.00	22.22	27.75	38.78
3	60.66	21.04	22.34	27.82	39.89
6	75.30	20.80	23.72	28.11	42.25
8	60.82	20.91	22.60	28.08	40.84

CV 1997 Stock size

Models	EurS	ColN	VanS	ColVan	CoastWide
1	65%	53%	60%	44%	58%
3	49%	45%	46%	45%	44%
6	43%	24%	27%	25%	25%
8	36%	37%	40%	39%	43%

Projected yield at $F_{40\%}$ by each stock group. Note that ColVan and Coastwide are not the sums of their subares, rather they are results from separate, agregated model runs.

Models	Year	EurS	ColN	VanS	ColVan	Coastwide
3	1998	353	1,995	1,063	2,577	1,603
3	1999	402	1,927	1,116	2,576	1,824
3	2000	450	1,906	1,187	2,664	2,122
3	2001	497	1,928	1,283	2,835	2,479
3	2002	541	1,970	1,393	3,040	2,829
8	1998	51	1,909	2,425	3,780	4,657
8	1999	91	1,852	2,308	3,626	4,650
8	2000	147	1,840	2,205	3,571	4,663
8	2001	213	1,869	2,145	3,615	4,728
8	2002	281	1,916	2,126	3,716	4,799

Table 10.17 Landings of yellowtail rockfish from Areas 3B+3C and 3D.

Year	3D	3B-3C	Total	% 3D
1967	82	2,049	2,131	4%
1968	23	1,991	2,014	1%
1969	91	2,060	2,151	4%
1970	136	2,106	2,242	6%
1971	132	2,103	2,235	6%
1972	71	2,043	2,114	3%
1973	23	1,996	2,019	1%
1974	109	2,083	2,192	5%
1975	6,774	8,749	15,523	44%
1976	2,369	4,345	6,714	35%
1977	182	2,159	2,341	8%
1978	37	2,015	2,052	2%
1979	116	2,095	2,211	5%
1980	64	2,044	2,108	3%
1981	27	2,008	2,035	1%
1982	13	1,995	2,008	1%
1983	36	2,019	2,055	2%
1984	19	2,003	2,022	1%
1985	288	2,273	2,561	11%
1986	3,083	5,069	8,152	38%
1987	1,978	3,965	5,943	33%
1988	2,037	4,025	6,062	34%
1989	1,270	3,259	4,529	28%
1990	1,888	3,878	5,766	33%
1991	2,044	4,035	6,079	34%
1992	1,656	3,648	5,304	31%
1993	1,603	3,596	5,199	31%
1994	1,579	3,573	5,152	31%
1995	1,145	3,140	4,285	27%
1996	2,018	4,014	6,032	33%
Totals	30,893	90,338	121,231	25%
Mean	1,030	3,011	4,041	25%
10-year mean	1,722	3,713	5,435	32%
5-year mean	1,600	3,594	5,194	31%

Table 10.18. Area 3C+3D trawl landings (t), effort (hr) and CPUE (t/hr) for canary rockfish

Year	Nat.	Total landings	Interviewed landings: landings	Interviewed landings: effort	Nominal CPUE	Median CPUE	25% qualified landings: landings	25% qualified landings: effort	25% qualified landings: Rolled-up Nominal CPUE	25% qualified landings: Tow-by-tow Nominal CPUE
1967	USA	578	575	4,471	0.13		-	-	-	
	Can	4	4	41	0.10		1	8	0.12	
1968	USA	938	902	2,838	0.32		0	0	-	
	Can	19	19	157	0.12		10	12	0.83	
1969	USA	779	746	3,647	0.20		-	-	-	
	Can	46	46	266	0.17		42	127	0.33	
1970	USA	990	938	4,785	0.20		-	-	-	
	Can	18	18	96	0.19		17	89	0.19	
1971	USA	1,011	962	3,009	0.32		-	-	-	
	Can	66	66	533	0.12		52	235	0.22	
1972	USA	294	292	2,969	0.10		-	-	-	
1973	USA	493	490	2,619	0.19		-	-	-	
1974	Can	26	26	461	0.06		15	26	0.58	
	USA	607	605	2,666	0.23		-	-	-	
1975	Can	14	14	186	0.08		9	10	0.9	
	USA	658	658	2,938	0.22		-	-	-	
1976	Can	193	193	822	0.23		157	207	0.76	
	USA	395	395	3,945	0.10		-	-	-	
1977	Can	196	196	1,808	0.12		109	147	0.74	
	USA	358	358	5,427	0.07		-	-	-	
1978	Can	68	68	434	0.16		40	56	0.71	
	USA	1,063	1,063	6,244	0.17		-	-	-	
1979	Can	122	114	680	0.17		94	175	0.54	
	USA	315	315	4,812	0.07		-	-	-	
1980	Can	126	126	1,058	0.12		109	204	0.53	
	USA	477	477	3,848	0.12		-	-	-	
1981	Can	66	66	929	0.07		42	84	0.5	
	USA	249	249	5,424	0.05		-	-	-	
1982	Can	316	316	1,415	0.22		286	309	0.93	
	USA	133	133	11,819	0.01		-	-	-	
1983	Can	853	647	1,723	0.38		593	1,049	0.57	
1984	Can	1,189	947	1,079	0.46		916	1,170	0.78	
1985	Can	903	611	1,897	0.32		557	779	0.72	
1986	Can	722	529	2,841	0.19		344	651	0.53	
1987	Can	695	600	2,535	0.24		462	670	0.69	
1988	Can	313	291	2,085	0.14		176	516	0.34	
1989	Can	1,173	1,154	6,520	0.18		854	1,862	0.46	
1990	Can	794	731	6,009	0.12		384	1,180	0.33	
1991	Can	652	632	7,287	0.09	120	302	1,061	0.28	0.38
1992	Can	774	763	7,810	0.10	120	421	1,484	0.28	0.36
1993	Can	835	817	8,342	0.09	120	502	1,347	0.37	0.40
1994	Can	765	747	7,564	0.10	135	508	1,315	0.39	0.45
1995	Can	623	603	7,146	0.08	124	421	900	0.47	0.51
1996	Can	306	264	3,262	0.08	**73**	168	290	0.58	0.58
Total		21,215								
Mean		707								
last 10 y		693								
last 5 y		661								

Notes
U.S. total landings equals Washington and Oregon combined.
U.S. interviewed landings from Washington only (Tagart and Kimura 1982).
Median CPUE in lbs/tow. 1991-1995 based on fisher logs, 1996 based on observer data

Table 10.19. Number of samples and number of aged canary rockfish

Year	3CD		5AB		5CD		5E		Total	
	Samples	Aged fish	Samples	Aged fish	Samples	Aged fish	Samples	Aged fish	Samples	Aged fish
1977	2	115	1	99	0	0	0	0	3	214
1978	1	104	4	387	4	387	1	100	10	978
1979	2	201	1	100	1	89	0	0	4	390
1980	0	0	1	100	2	200	0	0	3	300
1981	0	0	1	24	0	0	0	0	1	24
1982	2	50	1	27	0	0	0	0	3	77
1983	2	225	1	25	0	0	0	0	3	250
1984	3	212	0	0	0	0	0	0	3	212
1985	4	371	0	0	1	30	0	0	5	401
1986	2	75	0	0	0	0	0	0	2	75
1988	1	50	1	117	0	0	1	49	3	216
1989	1	25	0	0	0	0	0	0	1	25
1990	1	33	4	141	3	151	0	0	8	325
1991	2	102	4	206	2	101	0	0	8	409
1992	0	0	2	109	1	48	0	0	3	157
1993	3	151	1	81	0	0	0	0	4	232
1994	1	52	7	365	3	174	0	0	11	591
1995	4	211	0	0	1	50	0	0	5	261
Grand Total	31	1977	29	1781	18	1230	2	149	80	5137

Table 10.20 Area 5A and 5B trawl landings (excluding Moresby Gully) (t), effort (hr), and CPUE (t/hr) for silvergray rockfish

Year	Nat.	Total landings	Int. ldgs landings	Int. ldgs effort	Int. ldgs nominal CPUE	Int. ldgs median CPUE	25% Qualified landings	25% Qualified effort	25% Qualified nominal CPUE	25% Qualified Rolled-up CPUE	25% Qualified Tow-by-tow CPUE
1967	Can	87	89	539	0.17		63	200	0.32		
	USA	397	396	9,431	0.04		-	-	-		
1968	Can	78	78	644	0.12		37	109	0.34		
	USA	933	822	8,488	0.10		-	-	-		
1969	Can	78	78	1188	0.07		28	152	0.18		
	USA	1,291	1,276	13,557	0.09		-	-	-		
1970	Can	14	14	287	0.05		6	29	0.21		
	USA	189	189	9,264	0.02		-	-	-		
1971	Can	16	16	331	0.05		6	66	0.09		
	USA	521	512	7,137	0.07		-	-	-		
1972	Can	54	54	654	0.08		21	108	0.19		
	USA	251	251	9,224	0.03		-	-	-		
1973	Can	40	40	328	0.12		33	70	0.47		
	USA	189	189	9,625	0.02		-	-	-		
1974	Can	45	45	412	0.11		9	12	0.75		
	USA	377	377	8,797	0.04		-	-	-		
1975	Can	31	31	479	0.06		19	61	0.31		
	USA	306	306	5,179	0.06		-	-	-		
1976	Can	172	172	1,914	0.09		82	224	0.37		
	USA	443	443	4,620	0.10		-	-	-		
1977	Can	198	198	2,462	0.08		123	320	0.38		
	USA	440	440	5,165	0.09		-	-	-		
1978	Can	723	723	4,049	0.18		468	1,069	0.44	0.36	
	USA	57	57	909	0.06		-	-	-		
1979	Can	629	629	3,885	0.16		429	1,225	0.35	0.29	
	USA	298	298	1,696	0.18		-	-	-		
1980	Can	629	625	3,681	0.17		495	1,538	0.32	0.29	
	USA	147	147	1,146	0.13		-	-	-		
1981	Can	415	415	2,120	0.20		340	808	0.42	0.4	
1982	Can	618	597	4,099	0.15		430	1,208	0.36	0.33	
1983	Can	524	477	3,348	0.14		323	1,073	0.3	0.29	
1984	Can	982	718	3,481	0.21		642	1,948	0.33	0.31	
1985	Can	997	724	3,555	0.20		611	1,860	0.33	0.32	
1986	Can	700	564	3,812	0.15		388	1,314	0.3	0.27	
1987	Can	1,224	1,083	6,509	0.17		641	1,596	0.4	0.41	
1988	Can	1,051	1,016	7,232	0.14		596	1,554	0.38	0.35	
1989	Can	809	779	6,625	0.12		425	1,359	0.31	0.32	
1990	Can	730	697	7,420	0.09		347	1,116	0.31	0.29	
1991	Can	595	580	8,590	0.07	150	213	704	0.3	0.29	0.31
1992	Can	641	624	7,786	0.08	150	201	822	0.24	0.24	0.29
1993	Can	520	471	6,351	0.07	150	197	924	0.21	0.22	0.25
1994	Can	974	964	7,335	0.13	180	685	2,351	0.29	0.31	0.35
1995	Can	866	808	8,726	0.09	150	536	2,677	0.2	0.2	0.24
1996	Can	409	397	4575	0.09	**100**	243	610	n/a	n/a	**0.40**

Total	20688
Mean	714
last 10 y	782
last 5 y	682

(includes 738 t captured by foreign vessels in the 1970's)

Notes:

U.S. total landings equals Washington and Oregon combined.
U.S. interviewed landings from Washington only (Tagart and Kimura 1982).
Median CPUE in lbs/tow. 1991-1995 based on fisher logs, 1996 based on observer logs

Table 10.21. Area 5A+5B trawl landings (t), effort (hr) and CPUE of canary rockfish

Year	Nat.	Total landings	Interviewed landings: landings	effort	nominal CPUE	median CPUE		25% Qualified landings: landings	effort	nominal CPUE	tow-by-tow CPUE
1967	Can	41	41	535	0.08			13	32	0.41	
	USA	216	215	9,431	0.02			-	-	-	
1968	Can	49	49	576	0.09			31	78	0.40	
	USA	1,034	937	8,488	0.11			-	-	-	
1969	Can	67	67	733	0.09			37	110	0.34	
	USA	464	418	13,557	0.03			-	-	-	
1970	Can	6	6	80	0.08			4	12	0.33	
	USA	220	220	9,264	0.02			-	-	-	
1971	Can	18	18	329	0.05			6	8	0.75	
	USA	207	183	7,137	0.03			-	-	-	
1972	USA	61	61	9,224	0.01			-	-	-	
1973	Can	29	29	119	0.24			23	80	0.29	
	USA	298	298	9,625	0.03			-	-	-	
1974	Can	3	3	81	0.04			1	7	0.14	
	USA	257	257	8,797	0.03			-	-	-	
1975	Can	23	23	403	0.06			15	17	0.88	
	USA	189	189	5,179	0.04			-	-	-	
1976	Can	92	92	1,558	0.06			16	49	0.33	
	USA	447	447	4,620	0.10			-	-	-	
1977	Can	121	121	2,356	0.05			53	192	0.28	
	USA	288	288	5,165	0.06			-	-	-	
1978	Can	263	263	2,692	0.10			101	242	0.42	
	USA	8	8	909	0.01			-	-	-	
1979	Can	308	308	3,070	0.10			211	582	0.36	
	USA	62	62	1,696	0.04			-	-	-	
1980	Can	276	276	2,157	0.13			198	451	0.44	
	USA	88	88	1,146	0.08			-	-	-	
1981	Can	144	144	1,636	0.09			69	201	0.35	
1982	Can	358	330	3,203	0.10			210	706	0.30	
1983	Can	343	299	2,851	0.11			152	454	0.33	
1984	Can	507	321	2,506	0.13			228	686	0.33	
1985	Can	391	281	2,823	0.10			162	553	0.29	
1986	Can	262	211	2,931	0.07			64	253	0.25	
1987	Can	560	510	4,248	0.12			245	572	0.43	
1988	Can	544	529	5,792	0.09			195	652	0.30	
1989	Can	514	501	5,419	0.09			238	611	0.39	
1990	Can	519	498	6,526	0.08			149	577	0.26	
1991	Can	511	499	8,356	0.06	150		161	637	0.25	0.37
1992	Can	461	449	6,241	0.07	150		185	588	0.32	0.39
1993	Can	184	169	3,582	0.05	150		59	224	0.26	0.32
1994	Can	256	247	4,413	0.06	150		89	211	0.42	0.49
1995	Can	168	146	4,572	0.03	150		55	213	0.26	0.32
1996	Can	125	117	2832	0.04	**29**		60	91	n/a	**0.66**
Total		10,982									
Mean		366									
last 10 y		384									
last 5 y		239									

U.S. total landings equals Washington and Oregon combined.
U.S. interviewed landings form Washington only (Tagart and Kimura 1982).

Table 10. 22 Area 5C and 5D trawl landings and CPUE of silvergray rockfish

Year	Total landings	Interviewed landings: landings	effort	nominal CPUE	median CPUE	25% qualified landings: landings	effort	nominal CPUE	tow-by-tow CPUE
1971	34	34	229	0.15		24	121	0.20	
1972	61	61	232	0.26		44	54	0.81	
1973	10	10	147	0.07		-	-	-	
1974	13	13	64	0.20		11	34	0.33	
1975	11	11	190	0.06		4	5	0.79	
1976	118	118	1,440	0.08		55	414	0.13	
1977	232	232	2,019	0.12		142	468	0.30	
1978	235	235	1,413	0.17		177	301	0.59	
1979	429	429	3,029	0.14		285	701	0.41	
1980	346	344	1,938	0.18		186	396	0.47	
1981	456	415	1,762	0.24		343	311	1.10	
1982	259	238	1,799	0.13		149	212	0.70	
1983	451	348	1,108	0.31		289	337	0.86	
1984	647	383	2,081	0.18		315	710	0.44	
1985	1,043	729	2,133	0.34		578	458	1.26	
1986	1,082	1,056	1,796	0.59		1,024	927	1.10	
1987	763	632	1,928	0.33		531	592	0.90	
1988	893	881	3,270	0.27		625	1,064	0.59	
1989	743	741	2,731	0.27		538	1,063	0.51	
1990	587	568	3,689	0.15		360	861	0.42	
1991	320	319	3,286	0.10	120	193	470	0.41	0.50
1992	347	344	3,534	0.10	120	189	510	0.37	0.41
1993	478	469	3,916	0.12	120	295	774	0.38	0.45
1994	1,046	1,046	4,468	0.23	125	950	1,501	0.63	0.68
1995	567	564	4,439	0.13	120	451	1,037	0.44	0.48
1996	315	311	3,954	0.08	**56**	215	376	n/a	**0.57**
Total	11,486								
Mean	442								
last 10 y	606								
last 5 y	551								

Notes:
Used rolled-up landings data

Table 10.23 Area 5E-N and 5E-S trawl landings (t), effort (hr) and CPUE (t/h) of silvergray rockfish

Year	Region	Interviewed				25% Qualified	
		Landings	Effort	CPUE		Landings	Effort
1977	5E-N	0	0			0	0
1978	5E-N	16	91			16	21
1979	5E-N	8	95			0	0
1980	5E-N	15	17			15	17
1981	5E-N	2	10			0	0
1982	5E-N	38	56			27	9
1983	5E-N	16	108			1	1
1984	5E-N	248	731			61	33
1985	5E-N	245	1,258			158	219
1986	5E-N	172	1,772			35	39
1987	5E-N	85	1,004			6	21
1988	5E-N	131	1,521			40	76
1989	5E-N	333	1,555			188	361
1990	5E-N	137	1,208			65	133
1991	5E-N	19	64			16	28
1992	5E-N	5	17			5	16
1993	5E-N	34	79			30	31
1994	5E-N	109	239			109	113
1995	5E-N	111	195			111	106
1996	5E-N	69	162			65	38
Total		1,724					
Mean		86					
last 10 years		103					
last 5 years		66					
1977	5E-S	20	136	0.15		0	0
1978	5E-S	124	572	0.22		56	105
1979	5E-S	44	189	0.23		30	19
1980	5E-S	104	246	0.42		81	97
1981	5E-S	57	74	0.30		12	12
1982	5E-S	27	152	0.14		7	4
1983	5E-S	130	414	0.31		44	58
1984	5E-S	78	246	0.29		47	104
1985	5E-S	212	466	0.38		85	142
1986	5E-S	295	601	0.41		112	154
1987	5E-S	113	586	0.17		30	53
1988	5E-S	255	1,001	0.24		108	96
1989	5E-S	120	522	0.23		50	71
1990	5E-S	95	530	0.18		32	22
1991	5E-S	104	624	0.17		26	41
1992	5E-S	136	605	0.22		72	190
1993	5E-S	251	541	0.44		160	205
1994	5E-S	215	433	0.50		172	212
1995	5E-S	110	370	0.30		81	119
1996	5E-S	137	562	0.24		106	141
Total		2627					
Mean		131					
last 10 y		154					
last 5 y		170					