Canadian Trap-Fishery for Sablefish on Seamounts in the Northeastern Pacific Ocean, 1983-1993

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CANADIAN TRAP-FISHERY FOR SABLEFISH ON SEAMOUNTS IN THE NORTHEASTERN PACIFIC OCEAN, 1983-1993

by

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ABSTRACT

Murie, D.J., M.W. Saunders and G.A. McFarlane. 1996. Canadian trap-fishery for sablefish on seamounts in the northeastern Pacific Ocean, 1983-1993. Can. Manuscr. Rep. Fish. Aquat. Sci. 2348: 107 p.

Annual trends in effort, catch, and catch-per-unit-effort (CPUE) were examined for sablefish trapped on seamounts in the northeastern Pacific Ocean by Canadian vessels during 1983-1993. Annual mean lengths of sablefish trapped and the sex ratio of the catch was also analysed among years.

Sixteen seamounts were fished by Canadian vessels during 1983-93. Four of these seamounts, Bowie, Cobb, Union, and Warwick Seamounts, were fished consistently by the fleet since 1987/1988. Fishing effort directed towards the offshore seamounts increased and reached a maximum in 1991, both in the annual number of traps deployed and in the annual number of soak hours. Overall total catch in the fishery also peaked in 1991 at 395.5 t. The overall decrease in CPUE on the four major seamounts since 1990, however, suggests that sablefish stocks on these seamounts are not sustainable at current fishing levels. Bowie Seamount reached a maximum CPUE in 1988, which was followed by a continual decrease in CPUE. Cobb, Union, and Warwick Seamounts all had an increase in CPUE from 1988 to a maximum in 1990, which was followed by a precipitous decrease in CPUE in 1991.

CPUE for all seamounts pooled was greatest between depths of 457-822 m, which was similar to the slope fishery for sablefish. CPUE maxima, however, were attained at deeper depths of between 640 and 1005 m for Bowie, Cobb, Union, and Warwick Seamounts. Similar to the slope populations of sablefish, female sablefish on seamounts were larger than males. In contrast to the slope fishery, however, the sex ratio of catches from seamounts were consistently skewed towards a preponderance of males.

RÉSUMÉ

Murie, D.J., M.W. Saunders and G.A. McFarlane. 1996. Canadian trap-fishery for sablefish on seamounts in the northeastern Pacific Ocean, 1983-1993. Can. Manuscr. Rep. Fish. Aquat. Sci. 2348: 107 p.

Les auteurs ont procédé à un examen des tendances annuelles de l'effort de pêche, des prises et des prises par unité d'effort (PUE) de la pêche de la morue charbonnière faite au piège sur des monts sous-marins situés dans le nord-est de l'océan Pacifique. Cette pêche a été effectuée par des bateaux canadiens au cours de la période 1983-1993. La longueur moyenne et le rapport des sexes des poissons capturés au piège ont aussi été analysés en fonction des années.

Seize monts sous-marins ont été exploités par des bateaux canadiens de 1983 à 1993. Quatre d'entre eux, les monts Bowie, Cobb, Union et Warwick, font l'objet d'une pêche continue depuis 1987 ou 1988. L'effort de pêche exercé sur les monts sous-marins du large s'est accru et a atteint un maximum en 1991. L'augmentation annuelle de l'effort a porté tant sur le nombre de pièges utilisés que sur la durée du mouillage. Les prises totales de la pêche ont aussi atteint un maximum en 1991; elles s'élevaient alors à 395,5 t. La diminution générale du PUE notée pour les quatre principaux monts depuis 1990 porte cependant à croire que les stocks de morue charbonnière ne pourront se maintenir au niveau de pêche actuel. Au mont Bowie, le PUE maximum a été atteint en 1988, après quoi l'on note une baisse constante. Aux monts Cobb, Union et Warwick, le PUE a augmenté de 1988 à 1990 pour chuter ensuite en 1991.

La valeur de l'ensemble des PUE de tous les monts est la plus élevée dans la gamme des profondeurs de 457 à 822 m, ce qui est semblable à la pêche pratiquée sur les pentes. Les PUE maximums ont cependant été atteints à de plus grandes profondeurs, entre 640 et 1005 m, aux monts Bowie, Cobb, Union et Warwick. Comme pour les populations de morue charbonnière des pentes, les femelles des monts sous-marins étaient plus grosses que les mâles. Mais au contraire de la pêche sur les pentes, le rapport des sexes des poissons capturés sur les monts sous-marins était généralement biaisé en faveur des mâles.

INTRODUCTION

The commercial fishery for sablefish (*Anoplopoma fimbria*) comprises one of the most valuable groundfish fisheries in western Canada (Beamish and McFarlane 1988). In British Columbia, the commercial fishery takes place primarily on the continental slope or edge of the continental shelf between 400 and 1830 m (McFarlane and Beamish 1983a). Since 1981, the annual sablefish catch from slope areas has increased but there has been a concomitant decrease in the effort (i.e. number of fishing days) needed to fully utilise the total allowable catch [Department of Fisheries and Oceans (DFO) 1991a]. Management regulations for the sablefish fishery on the continental slope were initially aimed at regulating the number of vessels, and hence the effort, directed towards the sablefish fishery (i.e., limited entry licences in 1981) (McFarlane and Beamish 1983b). Further regulations were initiated as a means of allowing a reasonable number of fishing days and catch for each vessel [i.e., Individual Vessel Quota (IVQ) system in 1990] (DFO 1991a). The limitations placed on the commercial fishery for sablefish on the slope has spurred interest in locating any other oceanic areas that have an adequate biomass of sablefish to support a commercial fishery. Soviet and Japanese fishery surveys in the 1960's and 1970's identified seamounts as potential sources of previously unexploited fishery resources (Chikuni 1971; Sakiura 1972; Takahashi and Sasaki 1977; Kuroiwa and Funato 1980; Shigeno 1981; Uchida and Tagami 1984; Sasaki 1986).

Seamounts are elevations rising 1000 m or more from the sea floor and have a summit of limited extent (U.S. Board of Geographic Names 1969). They occur individually or as groups of mountains, pinnacles, or ridges, and are typically produced by undersea volcanic activity (Smith and Jordan 1988). Seamounts are among the most ubiquitous features of the ocean floor (Roden 1986) and it has been estimated that there are more than 30,000 seamounts over a kilometre high in the Pacific Ocean (Jordan and Smith 1988). It has been suggested that biological productivity increases over seamounts, which may be reflected in increased fish catches (Uda and Ishino 1958). This is due to an interaction between currents impinging on the seamount and the elevation and topography of the seamount. Relatively deep water may be deflected up, over or around the seamount bringing colder nutrient-laden water into shallower depths. The water mass at the base of the seamount can also be deflected upwards in a specific pattern that conserves the vorticity of the water movement forming a Taylor column, or a semistationary eddy, trapping the water and any productivity over the seamount (Roden 1986). Productivity of phytoplankton can therefore be greater over seamounts than in the nearby open ocean (Genin and Boehlert 1985; Dower *et al.* 1992) and this increased phytoplankton productivity can be transferred through to increased zooplankton (Genin and Boehlert 1985), increased micronekton (Boehlert and Seki 1984) and ultimately to an increase in fish productivity.

In 1967, Soviet trawlers discovered that significant quantities of commercially valuable fishes, in particular the pelagic armorhead (*Psuedopentaceros wheeleri*), could be profitably harvested from the southern Emperor Seamounts and seamounts in the northern Hawaiian Ridge (Sakiura 1972). In 1969, Japanese trawlers started exploratory fishing near the Milwaukee Seamounts (southern tip of the Emperor Seamounts) where they were able to successfully harvest pelagic armorhead. They also started harvesting alfonsin (*Beryx splendens*) from the seamounts, with the fishery reaching a profitable exploitation level in 1976 (Sasaki 1986). The profitable fishery for pelagic armorhead, and later alfonsin, stimulated interest in other unexploited seamount resources. Japanese trawlers initiated further searches for fishery resources on seamounts in the northeastern and northcentral Pacific Ocean (Takahashi and Sasaki 1977), in the central South Pacific Ocean, the Indian Ocean, and the South Atlantic Ocean (Sasaki 1986). Groundfish surveys over seamounts in the northeastern Pacific Ocean reported concentrations of various rockfish (*Sebastes*) species, as well as sablefish (Chikuni 1971). Trawl fishery surveys by the Fisheries Agency in Japan and the Japan Marine Fishery Resource Research Centre in 1978 and 1979 captured primarily rockfish species on Warwick and Cobb Seamounts in the northeastern Pacific Ocean. However, they also caught a limited amount of sablefish (Kuroiwa and Funato 1980; Shigeno 1981). The presence of sizeable populations of commercially exploitable fish species on seamounts also stimulated the U.S. National Marine Fisheries Service (NMFS) to investigate resources associated with seamounts in the Gulf of Alaska in 1979 (Hughes 1981). It was apparent from the NMFS trap surveys that sablefish dominated the demersal fish communities on Alaskan seamounts (Hughes 1981; Alton 1986).

Seamounts off the coast of B.C. were therefore anticipated to potentially harbour a source of sablefish that would be adequate to support a secondary commercial fishery. Since 1983 Canadian sablefish vessels have harvested sablefish from seamounts in the northeastern Pacific Ocean under a scientific (experimental) fishing permit. The Department of Fisheries and Oceans Canada established an experimental/scientific status for the seamount fishery in order to assess its potential as a sustainable commercial fishery. The permits were also necessary as a means of managing and regulating the harvest of sablefish from seamounts independently of the sablefish harvest from slope areas. During this fishery, catch, effort, and biological data were collected for sablefish populations. This report summarizes the Canadian experimental trap-fishery for sablefish on offshore seamounts during 1983 to 1993. The primary objective was to determine the annual trends in catch, effort, and catch-per-unit-effort (CPUE) among years and among seamounts. Biological data was also analysed to determine differences in annual mean lengths and sex ratios of male and female sablefish sampled from offshore seamounts.

METHODS

FISHING SITES

Sablefish were fished by Canadian vessels on 16 offshore seamounts in the northeastern Pacific Ocean (Figure 1) during 1983-1993. Much of the specifics of the physiography (e.g., elevation, currents, etc.) of these seamounts is unknown. In general, the seamounts have peaks or tables with summit depths of less than 1000 m, steep slopes, bases in approximately 2000-3000 m depth, and have a limited area (Table 1). Bowie and Cobb Seamounts have minimum depths (14 and 24 m respectively) that reach into the euphotic zone. Two are presently unnamed and have been assigned provisional names for this report (Seamount XX and Seamount XY).

Six of the 16 seamounts are located within Canada's 200-nm Fishery Conservation Zone and ten are in international waters (Figure 1). Seamounts offshore of the 200-nm zone may therefore have been fished by non-Canadian vessels; however, a record of their catch was not available. This report therefore summarizes and analyses only catches from Canadian vessels.

FISHING GEAR AND METHODS

Sablefish on seamounts were fished using three different gears: traps, longlines, and trawls. This report summarizes the fishery that employed traps only (Table 2) because traps have been the main method of fishing for sablefish since 1980 (McFarlane and Beamish 1983b). This did not compromise the data base since trap fishing represented 94% (47/50) of all seamount trips targeting sablefish between 1983 and 1993. Fishing statistics for trips involving the use of longlines with baited hooks (Appendix Table 1) or trawls (Appendix Table 2) to capture sablefish were not analysed. In addition, seamount trips (or portions of trips) that did not target specifically on sablefish were not included in the analyses (Appendix Tables 3 and 4).

Prior to 1989, members of the sablefish fleet were required to maintain vessel logs detailing the date, location, and quantity of their catch. Since 1989, each vessel has also been required to carry a fishery observer as a condition of their scientific (experimental) fishing permit. The following summary of fishing operations was obtained from a composite of all observers' logs.

Vessels fishing over seamounts used either rectangular or Korean conical traps [137-147 cm (54-58" diam)] with tunnel entrances. Typically, traps were baited with a mixture of frozen hake and squid, but occasionally were baited with herring and squid, or squid alone. Traps were deployed to the bottom using a weighted longline, with traps attached to the longline every 45.7 m (25 fm). The duration of time that the traps were on the bottom fishing was the soak time. Soak time was calculated as the elapsed period of time between the first trap entering the water and the first trap being retrieved onboard. Each fishing set consisted of a string of 30-100 traps. Information recorded for each set included: date, set number, starting location of the set, finish location of the set, set direction, minimum and maximum depth of the set, starting time for the set, duration of the set (soak time), method of estimating catch and species composition, number and/or weight of all species caught in the set, utilisation of the species caught, number of traps set, and number of traps lost from the set.

Based on general comments in fishing logs, the decision to move to another area or another seamount was based on the lack of a suitable catch of sablefish from the site being fished. In most instances, a vessel would not leave a site producing a large bycatch [e.g., rougheye rockfish, (*Sebastes aleutianus*)] if the site still provided an adequate sablefish catch. Sites giving a large bycatch in conjunction with a small sablefish catch were abandoned.

All legal-sized sablefish [>55 cm fork length (FL)] were retained by the vessel for sale. Sublegal-sized sablefish were immediately returned to the water as discards. Retained sablefish were processed onboard with a Japanese-cut (J-cut), blast frozen on plates, glazed with seawater, and stored frozen. On one vessel the retained sablefish were J-cut and then iced down for transport rather than frozen.

The majority of skippers estimated the quantity of sablefish caught in each set by comparing the volume of fish in the deck totes with the known weight of a full deck tote of fish. Fishery observers on these vessels used the skipper's estimation of catch. Alternatively, observers counted all fish in each set and then multiplied this number by an average fish weight to obtain a total weight for each set. In 1989 and 1990, the quantity of sablefish captured in each set was recorded as number of pieces without corresponding weights. For these vessel logs, an average weight per fish was estimated by determining the mean fork length of retained sablefish (i.e., those fish >55 cm FL) from length-frequency samples taken onboard the vessel. This FL was incorporated into equation [1] to estimate an average fish weight:

[1] $\text{Weight (kg)} = 1.4 \times 10^{-6}\ \text{FL(cm)}^{3.5025}$ (McFarlane and Beamish 1983a).

RESOLVING CATCH WEIGHTS

While at sea, the weight of the sablefish catch for each set was a visual estimate that could not be ground-truthed until the vessel reached port and offloaded its catch. During offloading, the total weight of the J-cut frozen (or J-cut fresh) sablefish landed was accurately weighed using scales. Offloaded weight was the combined total weight for all sets of the trip. Discrepancies between the total estimated weight of sablefish caught versus the total known weight of sablefish landed were resolved through calculation of a multiplication factor specific for each trip[a]. This factor was calculated by:

1) Converting the landed weight of frozen J-cut sablefish into a landed weight of fresh round sablefish by multiplying the frozen weight by 1.4800 (DFO 1991b). This conversion factor takes into account a 4% glaze allowance for the frozen product (DFO 1991a). If the catch was landed as J-cut fresh sablefish then the landed weight was multiplied by 1.5108 to convert it into fresh round weight (DFO 1991b). This conversion factor takes into account a 2% slime and ice allowance for fresh product (DFO 1991a). This quantity of landed fresh round sablefish in pounds was then converted into kilograms by dividing by 2.2046.

2) Converting the weight of fresh J-cut sablefish estimated at sea into a weight of fresh round sablefish by multiplying the estimated weight by 1.5108. The majority of estimated catch weights made by observers at sea were already recorded in kilograms; others were converted from pounds to kilograms by dividing by 2.2046.

3) Dividing the landed weight of fresh round sablefish by the estimated weight of fresh round sablefish to calculate a multiplication factor for the trip. This factor was 1.0 only when the landed and estimated weights for the total catch were identical. A factor <1.0 indicated that the weight at sea had been overestimated, and a factor >1.0 indicated that the weight of the catch at sea had been underestimated.

This multiplication factor was then applied to the estimated weights of each individual set in a trip to correct for under- or over- visual estimation by the skipper/observer. The corrected weights for each set in a trip were taken to be the resolved catch weights, and only resolved catch weights were used in the following analyses.

ESTIMATING CATCH-PER-UNIT-EFFORT

Catch-per-unit-effort (CPUE) was determined for individual sets for trips during 1983-1993. CPUE was calculated by dividing the resolved catch weight for the set by the number of traps retrieved from the set, to give CPUE in kg sablefish per trap. This method of calculating CPUE has been used in research surveys and in stock

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[a] Department of Fisheries and Oceans Canada uses the same method when processing logs for the commercial sablefish fishery to resolve differences in the estimated catches recorded in logbooks with the known offloaded catches (pers. comm., K. Rutherford, Department of Fisheries and Oceans, Pacific Biological Station, Nanaimo, B.C.).

assessments for the commercial sablefish fishery. In these surveys and in the fishery, however, the soak times are relatively short and consistent (e.g., ~24-36 hr) (Saunders *et al.* 1995). The calculation of CPUE (kg/trap) has therefore been restricted to a narrow range of soak times.

For the seamount fishery, however, the mean soak time for all sets pooled was 53.0 ± 0.9 hr (Mean ± SE, n=2297 sets), with a range of 9-282 hr (i.e., <1 day to >11 days). Soak times for the seamount fishery were variable because they depended mainly on the feasibility of turning over the strings of traps and the offshore weather pattern. Restricting the calculation of CPUE to sets <36 hr was therefore not feasible for the seamount fishery.

The relationship between CPUE (kg/trap) as a function of soak time for the seamount fishery indicated that CPUE (kg/trap) gradually increased with increased soak time (Figure 2). The variation in CPUE (i.e., as indicated by the standard error bars), however, also increased with increased soak time. In contrast, CPUE calculated in kg per trap per soak hour as a function of soak time was a decreasing function approximating an exponential decay (Figure 2). In general, this relationship indicated that the greatest CPUE (kg/trap/hr) and the most variable CPUE was obtained within the first 20 hr of the set. In sets of >20 hr the CPUE (kg/trap/hr) decreased but the CPUE was more consistent. At soak times of ~65-75 hr the decay function levelled-off and CPUE (kg/trap/hr) remained around 0.15 kg/trap/hr.

For the seamount fishery, therefore, it was more appropriate to restrict the analyses to sets with soak times of 20-70 hr to reduce the influence on CPUE (kg/trap) of extremely short or excessively long soaks. This range of soak times was within the range observed in research surveys and in the commercial fishery (i.e., 1-3 days). Under this criterion, 76% of all sets were included in the analyses. This calculation of CPUE assumes a linear function between the catch and the number of traps (i.e., CPUE is calculated as a ratio of kg/trap). In future, it may be appropriate to develop a more complex model describing the relationship between these parameters that does not assume linearity. At present, we have used the linear approach in the calculation of CPUE for consistency and comparison. Unless otherwise noted, CPUE refers to CPUE in kg/trap for sets with 20-70 hr soaks (i.e., a qualified-CPUE).

This approach appeared to be reasonable in that the annual mean CPUE for all seamounts combined that was qualified by 20-70 hr soaks (Figure 3) showed the same trend in CPUE as the annual mean CPUE based on all sets regardless of soak time (Figure 4). This overall CPUE for the fishery was comprised of CPUE from all of the individual seamounts. Individual seamounts, however, may have separate stocks of fish because the seamounts are relatively isolated structures. On this basis, it was more appropriate for further detailed analyses of CPUE to be based on CPUE for individual seamounts.

CPUE values were determined for individual seamounts by year and month to assess annual and seasonal trends in catch rates. Detailed analyses of annual CPUE and depth-related changes in CPUE were restricted to seamounts that were fished for more than four years. These analyses included four major seamounts: Bowie, Cobb, Union, and Warwick. Changes in CPUE with depth were determined using an average depth for each set, which was calculated by taking the average of the start and the end depths. Depth was stratified into six 182-m (100-fm) categories: 274-456 m (150-249 fm), 457-639 m (250-349 fm), 640-822 m (350-449 fm), 823-1005 m (450-549 fm), 1006-1188 m (550-649 fm), and >1188 m (>649 fm) (modified from Saunders *et al.* 1994). Annual differences in CPUE for individual seamounts among years and depths were analysed using an analysis of variance (ANOVA) (General Linear Model) followed by a Student-Newman-Keuls (SNK) test when the ANOVA was statistically significant ($P \leq 0.05$) (Zar 1984).

BIOLOGICAL SAMPLING

From 1983-1988, vessels retained a sample of frozen round sablefish for delivery to port observers. These fish were thawed prior to sampling for length, sex, and age (L/S/A sample) (Table 2). From 1989-1993, fresh round sablefish were sampled by observers for length and sex (L/S sample), length, sex and age (L/S/A sample), or length, sex, age and stomachs (L/S/A/STOM sample) (Table 2). Random samples were obtained either from sampling every fish in every trap in the set or by estimating the number of traps to be sampled in order to get an adequate sample size, usually a minimum of 50 fish (e.g., sampled every third trap). For L/S samples, fish were measured in the round for FL to the nearest cm and internally sexed during processing. For L/S/A samples, fish were measured for FL to the nearest mm, sexed internally, and the sagittal otoliths were removed and stored for ageing. L/S/A samples were analysed for length and sex only because to date few of the samples have been aged. For samples involving collection of stomachs or gastrointestinal tracts, either the contents were examined by the fishery observer while onboard the vessel or else the stomach/GI tract was bagged, labelled, and frozen for later processing. Length and sex were not analysed from L/S/A/STOM samples unless the sample was random. L/S/A/STOM samples taken for selective size-groups of fish were not included in the length frequencies.

Length frequencies were determined for male and female sablefish sampled from individual seamounts in each year to determine annual trends in length frequencies. Fish that were not sexed or that were of unknown sex were excluded from the analyses. Differences in mean lengths among years were examined using ANOVA's. Deviations of the length and sex samples from a 1:1 sex ratio were examined using Chi-square analysis. Depth-related differences in the proportion of the sexes in the catch was determined by examining the proportion of males and the proportion of females in each set as a function of the average depth of the set. Proportions of males and females were arcsine transformed to correct for non-normality prior to curve fitting (Zar 1984). This analysis was done with sets fished on Bowie Seamount in 1991-1993 because it was fished over a wide range of depths.

Biological samples for rougheye rockfish and shortraker rockfish (*Sebastes borealis*) collected from trips targeting on sablefish were tabulated only (Appendix Tables 5, 6 and 7).

RESULTS

ANNUAL TRENDS IN EFFORT AND CATCH

The number of seamounts fished, the number of individual vessels involved in the seamount fishery, and the number of annual trips to the seamounts have all increased since 1987, with the fishery peaking in 1992 (Figure 5).

Relative to the total catch of sablefish, however, the seamount fishery peaked in 1991 with a total catch of 395.5 tonnes (Figure 6). Total number of traps deployed by the fishery and total soak hours involved in the fishery also peaked in 1991 (40,555 traps and 42,555 hrs) (Figure 6). Total catch, total number of traps, and total number of soak hours in the fishery all followed a similar trend among years, with increased total catch correlated with increased number of traps and increased soak time.

VARIATION IN EFFORT, CATCH, AND CPUE AMONG SEAMOUNTS

Annual fishing effort (i.e., number of traps and soak hours) directed towards Bowie Seamount was consistently greater than for any of the other major seamounts in the fishery (Figures 7, 8). Fishing effort increased on all of the major seamounts in 1991. In particular, both the number of traps and the number of soak hours increased substantially on Bowie Seamount in 1991, reaching a maximum. For both Bowie and Cobb Seamounts, effort decreased after 1991 whereas effort continued to increase on Union and Warwick Seamounts in 1992. Effort on all of the major seamounts decreased in 1993.

Bowie Seamount was fished by Canadian vessels between 1985 and 1993, although catch data was only available for 1987-1993 (Figure 9). The increase in effort on Bowie Seamount in 1991 (Figures 7, 8) was correlated with an increase in the total catch from the seamount in 1991 (Figure 9). Since 1991, however, the total catch on Bowie Seamount has decreased. CPUE also changed significantly during 1987-1993 ($F=104.79$, $P<0.001$) (Figure 9, Table 3). CPUE was at a maximum and was significantly greater on Bowie in 1988 compared to 1989, and was at an all-time low in 1993 (Appendix Table 8).

Cobb Seamount was fished in 1983 and 1985 (catch data unavailable) but has only been fished consistently since 1988 (Figure 10). Total catch increased on Cobb Seamount in 1990, remained high in 1991, and has since decreased. Cobb Seamount was not fished by Canadian vessels in 1993. This seamount also showed significant differences in CPUE over time ($F=51.93$, $P<0.001$) (Figure 10, Table 4). In 1983, fishing was characterised by low effort (Figures 7, 8) and higher catch (Figure 10), which produced the highest CPUE over all years (Figure 10) (Appendix Table 8). This was followed by a decrease in CPUE in 1990, with lower CPUE observed in 1988 and 1991 when compared to 1988 and 1992 (Appendix Table 8).

Union Seamount was also fished in 1983 and 1985 (catch data unavailable) but was not fished consistently until 1988 (Figure 11). Catch was at a maximum in 1989 and decreased precipitously in 1990. Catch increased again in 1991 but has since declined to a low level. CPUE for Union has also changed significantly over the years ($F=13.18$, $P<0.001$) (Figure 11, Table 5). Differences among years was a graded response, however, with CPUE decreasing in steps from 1990, 1989, 1988, 1991, 1993 and 1992 (Appendix Table 8). As with Cobb Seamount, fishing on Union Seamount in 1983 was notable for the low effort (Figures 7, 8) with a reasonably high catch (Figure 11), which in turn yielded the greatest CPUE over all years (Figure 11) (Appendix Table 8).

Warwick Seamount has been fished consistently by Canadian vessels since 1988 (Figure 12); catch data were unavailable for 1985. During 1989 and 1990 catch increased on Warwick Seamount from its all time low in 1988. Catch again increased in 1992 but was followed by a marked decline in catch in 1993. Again there were significant differences in CPUE during 1988-1993 ($F=11.13$, $P<0.001$) (Figure 12, Table 6). CPUE was greatest on Warwick Seamount in 1990 compared to all other years (Appendix Table 8).

Overall, Cobb, Union, and Warwick Seamounts showed a similar increase in CPUE from 1988 to 1990, followed by a marked decrease in CPUE in 1991 (Figure 13). This 1990 peak in CPUE was not observed on Bowie Seamount. CPUE on Bowie Seamount reached a maximum in 1988 and has since declined. In 1990, however, CPUE for all the major seamounts was similar and ranged from 12.6-16.6 kg/trap. CPUE on these major seamounts has remained low in 1992 and 1993.

For seamounts fished for 1-4 years only (i.e., "minor" seamounts), CPUE ranged from 0.06-16.42 kg/trap (Table 7). Data for these seamounts were insufficient for any further analyses.

VARIATION IN EFFORT AND CPUE AMONG MONTHS

Prior to 1991, Bowie Seamount was fished only during May, June, and July (Table 3). Since 1991, the fishing season has extended from April to October. Overall years, however, the majority of sets were fished in May (20%), June (31%), and July (18%). Cobb Seamount was also fished mainly during April (35% of sets), May (20%), and June (19%) (Table 4). Union Seamount was fished primarily during April to June (50% of sets) and August to September (45%) (Table 5). Warwick Seamount was also fished mainly during April to June (63% of sets) and August to September (32%) (Table 6).

Analysis of monthly changes in CPUE was limited to Bowie Seamount during 1991-1993 because this seamount was consistently fished in each year from April to August (Table 3). Months fished were not consistent enough throughout the years on Cobb, Union, or Warwick Seamounts to permit analyses of monthly changes in CPUE (Tables 4, 5, and 6). In 1991, CPUE on Bowie Seamount increased from April to August and then decreased to a minimum in November (Figure 14). CPUE in 1992 was greatest in April, the first month fished, then decreased over May and June. CPUE in 1992 also increased slightly in July and then decreased to low levels throughout August, September, and October. CPUE in 1993 reached maxima in May and July, and was at an all time low in June. CPUE was consistently lower in 1993 in all months compared to 1991 and 1992.

VARIATION IN EFFORT AND CPUE AMONG DEPTH STRATA

Of the 1737 sets that had depth reported and were 20-70 hr soaks, 3% were fished at depths <274 m, 4% at depths of 274-456 m, 14% at depths of 457-639 m, 34% at depths of 640-822 m, 32% at depths of 823-1005 m, 11% at depths of 1006-1188 m, and 2% at depths >1188 m.

Overall there was a trend towards a greater CPUE in the 457-639 m and 640-822 m depth strata (Figure 15) when all years and all seamounts were pooled. CPUE was lower in the <274 m, 274-456 m, and 823-1005 m depth strata. CPUE decreased in depth strata >1005 m.

The majority (57%) of sets on Bowie Seamount were fished between 640 and 1005 m (542/954 sets). Over 30% of sets were fished in shallower water: 19% in 457-639 m, 7% in 274-456 m, and 5% in <274 m. Approximately 12% of sets were fished in waters >1005 m: 10% in 1006-1188 m and 2% in >1188 m. There were significant differences in CPUE among the different depth strata on Bowie Seamount (F=8.74, P<0.001) (Figure 16). The greatest CPUE was obtained in the depth stratum of 640-822 m, and the lowest CPUE was observed in strata of 274-456 m and 1006-1188 m (Appendix Table 8).

On Cobb Seamount, 70% (141/201 sets) of sets were fished between 640 and 1005 m. Fishing at depths of 457-639 m and 1006-1188 m represented 15% and 12% of all sets, respectively. There were too few sets fished at depths <457 m (n=3) and >1188 m (n=2) so these depth strata were excluded from the depth analysis (2% of all sets). CPUE on Cobb was also significantly different among the remaining depth strata (F=4.12, P=0.003), with the greatest CPUE in depths between 823-1005 m (Figure 16). CPUE was similar in depths between 457-822 m and 1006-1188 m (Appendix Table 8).

The majority (75%) of sets on Union Seamount were fished in 640-1005 m (124/165 sets). Few sets were fished at depths of 457-639 m (<1%) or > 1005 m (<2% of sets). There were only a few fishing sets on Union Seamount in depths <457 m (n=3) so the shallowest depth stratum was excluded from the analysis. Although CPUE tended to be greater at depths of 823-1005 m, there was no significant difference in CPUE among the depth strata on Union Seamount (F=0.95, P=0.419) (Figure 16) (Appendix Table 8).

As with Union Seamount, the shallowest depth stratum on Warwick Seamount was excluded from analysis due to the low number of sets (n=2), as was the deepest (n=1). The majority of sets (76%) on Union Seamount were fished between 640-1005 m (99/130 sets). Fishing in depths of 1006-1188 m represented ~11% of all sets and 10% were fished in 457-639 m. CPUE appeared to be the greatest at 640-822 m, although it was not significantly different than CPUE at depths <640 m or >822 m (F=1.44, P=0.224) (Figure 16) (Appendix Table 8).

The majority of all sets for each of the major seamounts were fished between 640 and 1005 m. Overall, Bowie Seamount had greater CPUE in depths <822 m when compared to the other major seamounts (Figure 16). Maximum CPUE among the four major seamounts, however, occurred in depths between 640 m and 1005 m. Seamounts were not fished to any extent at depths <457 m or >1188 m, with the exception of shallow sets on Bowie Seamount.

LENGTH FREQUENCIES

Bowie Seamount

Mean lengths of male sablefish sampled from Bowie Seamount differed significantly among years (1985-1993) (F=106.55, P<0.0001) (Figure 17A, Table 8). Males sampled in 1988 had shorter fork lengths than males sampled in 1987 or 1989, which in turn were significantly shorter than males sampled in 1985 (Appendix Table 9). Males measured in 1985 were shorter than males measured in 1990, and males in 1990 were shorter than males sampled in 1991-1993. Length-frequencies for male sablefish sampled from Bowie Seamount ranged between 44 and 90 cm (Figure 18).

Female sablefish sampled from Bowie Seamount also differed in mean lengths among years (1985-1993) (F=33.33, P<0.0001) (Figure 17A, Table 8). Similar to male sablefish collected from Bowie Seamount, females sampled in 1988 were shorter than females collected in 1989, which were shorter than females sampled in 1987, 1990, and 1991 (Appendix Table 9). Fish sampled in 1987 and 1991 were shorter than fish caught in 1990, 1992, 1993, and 1985. Female sablefish sampled from Bowie Seamount ranged between 42 and 93 cm in fork length (Figure 18).

Cobb Seamount

Male sablefish sampled from Cobb Seamount during 1983-1992 differed among years in mean fork length (F=6.85, P<0.0001) (Figure 17B, Table 8). Males sampled in 1983 were shorter on average than males collected in 1985 and 1989-1991 (Appendix Table 9). Males sampled in 1992 were longer than males sampled in any other year. Males collected from Cobb Seamount ranged in length from 49 to 89 cm (Figure 19).

Females sampled from Cobb Seamount during 1983-1992 also differed in mean length among years (F=7.83, P<0.0001) (Figure 17B, Table 8). Females collected in 1989 and 1990 were shorter than females sampled during 1983, 1985, or 1992 (Appendix Table 9). Females sampled in 1991 were not different in length than females from any other year. Female sablefish sampled from Cobb Seamount exhibited a wide range in size, from 49 to 99 cm (Figure 19).

Union Seamount

Mean lengths of male sablefish on Union Seamount differed during 1983-1993 (F=54.91, P<0.0001) (Figure 17C, Table 8). Males sampled in 1988 were shorter than males in 1983 and 1985 (Appendix Table 9). These males were in turn shorter than males sampled in 1990 and 1992, which were shorter than males collected during 1989, 1991, and 1993. Length frequencies for males ranged between 47 and 87 cm (Figure 20), except for 1988 where all males were <65 cm.

Female sablefish sampled on Union Seamount during 1983-1993 only differed in size with respect to the 1988 sample in which the fish were shorter than in any other year (F=8.24, P<0.0001) (Figure 17C, Table 8) (Appendix Table 9). However, female sablefish were not represented adequately in the small 1988 sample (Figure 20). Females ranged in size from 52 to 97 cm (Figure 20).

Warwick Seamount

Male sablefish sampled from Warwick Seamount during 1985-1993 differed in mean fork length among years (F=6.33, P<0.0001) (Figure 17D, Table 8). Overall, males sampled in 1985 and 1989 were shorter than males collected in 1990, 1991, and 1993 (Appendix Table 9). Males collected in 1992 were not significantly different in length than males sampled from any other year. Males ranged in size from 49 to 88 cm (Figure 21).

Mean fork lengths of female sablefish sampled from Warwick Seamount were not different from 1985 to 1993 (F=2.22, P=0.0648) (Figure 17D, Table 8) (Appendix Table 9). Females ranged in size from 53 to 92 cm (Figure 21).

Minor Seamounts

Length frequencies for male and female sablefish sampled on Brown Bear (1991, 1992), Far Cobb (1990, 1991), Eickelberg (1985, 1991, 1992), and Hodgkins (1985, 1991, 1992) Seamounts were similar in range to those observed on the major seamounts (Figure 22). Length frequencies for all other minor seamounts were available for only 1992, with the exception of Dellwood Seamount which was sampled in 1987 (Figure 23). Some of these minor seamounts showed an increased percentage of female sablefish >84 cm in length (e.g., Cowie, Heck, Murray, and Surveyor Seamounts) compared to the major seamounts.

Mean fork lengths for male sablefish sampled from minor seamounts ranged between 58.5 and 65.6 cm (Table 9). For female sablefish, the average fork lengths ranged between 66.3 and 81.0 cm (Table 9).

SEX-SPECIFIC SIZES AND SEX RATIOS

Female sablefish captured on Bowie, Cobb, Union and Warwick Seamounts were longer, on average, than male sablefish (Figure 17). Lengths of males and females on Bowie Seamount overlapped in the range of ~60-75 cm fork length (Figure 18). Females from Cobb Seamount almost completely overlapped the size range for males, although males were not distributed into the upper size range of females (Figure 19). In contrast, there was little overlap in the sizes of male and female sablefish sampled from Union Seamount (~63-70 cm) (Figure 20). On Warwick Seamount, males and females overlapped in lengths mainly between 62 and 73 cm (Figure 21).

Overlap in the length frequencies of male and female sablefish on minor seamounts varied considerably. Length frequencies ranged from having relatively little overlap between the sexes (e.g., Murray Seamount in 1992) (Figure 23) to having almost complete overlap (e.g., Brown Bear Seamount in 1991) (Figure 22).

With one exception, sex ratios of sablefish sampled from Bowie, Cobb, Union, and Warwick Seamounts were all skewed towards a predominance of males (Table 8). The one difference observed was in 1987 on Bowie Seamount were there was equal representation of males and females in the samples. The bias towards males also held for most of the minor seamounts (Table 9). With these seamounts, over 65% of samples (12/18) on an annual basis were skewed towards males, one small sample was skewed towards females, and five samples had equal representation of males and females.

The proportion of males and females in the catch in relation to the depth of the sets on Bowie Seamount in 1991-1993 was highly variable but significant when fit to a second-order polynomial (males: F=12.70, P=0.00, r^2=0.12; females: F=12.69, P=0.00, r^2=0.13) (Figure 24). Linear curve-fitting was rejected due to a decreased fit (r^2=0.00) and nonsignificant regression (P=0.39). Despite the low r^2's for the polynomial curve-fits, the general trend was for the proportion of males in the catch to be greatest at mid-depths (~600-1000 m) and to decrease in shallower and deeper sets (Figure 24). Logically, the trend was the opposite for females with the proportion in the catch being greater in shallower and deeper sets and less in mid-depth sets.

DISCUSSION

CATCH, EFFORT, AND CPUE ON SEAMOUNTS

The total catch of sablefish from all seamounts combined increased during 1991 and 1992 (Figure 3). This increase in catch was concomitant with a doubling of effort, both in soak hours and number of traps deployed (Figure 6). In part, this increase in effort in 1991 and 1992 was due to an increase in the number of vessels participating in the fishery and an increase in the number of individual seamounts fished (Figure 5). The increase in the number of individual seamounts fished in 1992 was mainly due to relatively minor seamounts being fished for the first time (e.g., Heck, Pratt, Cowie, Murray, XX, and XY). These fishing trips were usually designated as "exploratory" by the skipper of the vessel. They were usually of short duration due to either a lack of abundant sablefish or a shortage of fishing space (i.e., the area of the seamount was small). CPUE on these seamounts was variable, however, ranging from very poor on Heck Seamount (0.06 kg/trap) to relatively high on Seamount XX (10.57 kg/trap) (Table 7).

The decrease in CPUE of sablefish on the four major seamounts in the northeastern Pacific Ocean since 1990 (Figure 13) suggests that populations of sablefish on these seamounts are not sustainable at current fishing levels. Catch rates of sablefish from Bowie Seamount (Figure 13) prior to 1991 surpassed the catch rates in the commercial fishery operating on the continental slope (1978-1987 average=12-18 kg/trap, McFarlane and Beamish 1983b, Saunders *et al.* 1994). CPUE for Cobb, Union, and Warwick Seamounts in 1990 was comparable with the slope fishery. Catch rates of sablefish trapped on Alaskan seamounts have been observed to be higher than catch rates from National Marine Fishery Service (NMFS) surveys off southeastern Alaska (Alton 1986). Experience with pelagic armorhead stocks on the southern Emperor Seamounts and seamounts of the northern Hawaiian Ridge, however, would suggest that these catch rates are not sustainable over time (Sasaki 1986). Pelagic armorhead stocks were fished at a level of 20,000-30,000 tonnes for 5 yrs (1972-76). This catch was sustained because of a large increase in effort during this time period, despite a significant and continuous decrease in CPUE since 1972-73. In 1977, the catch dropped to only 3,500 tonnes as the fishery crashed (Sasaki 1986).

Heavy trawling pressure for pelagic armorhead on these seamounts therefore resulted in depleted stocks in a relatively short time (Sasaki 1986). An intensive trawl fishery prior to 1985 has also been implicated in the depletion of rockfish stocks on Cobb Seamount (Sasaki 1986); although the effect of the fishing pressure on specific rockfish stocks is debatable (Pearson *et al.* 1993).

The large increase in effort in the seamount fishery observed in 1991 was primarily due to an increase in effort on Bowie Seamount, both in the number of traps deployed (Figure 7) and in the total number of soak hours (Figure 8). The large fishing effort directed at Bowie Seamount was most likely a combination of its relative closeness to coastal British Columbia (Figure 1) and previous experience by skippers of relatively high catch rates.

The seamount fishery operated in slightly deeper waters than the commercial sablefish fishery operating off the continental slope. Overall average CPUE in the seamount fishery was greatest at depths of 457-822 m (250-449 fm) (Figure 15). CPUE on each of the major seamounts was highest between 640-1005 m (350-549 fm) (Figure 16). Bowie Seamount was the only major seamount with substantial CPUE at depths of <457 m (Figure 16). The majority of the fishing effort on Bowie, Cobb, Union, and Warwick Seamounts was also directed at depths between 640 m and 1005 m. In comparison, the commercial slope fishery operates between 274 and 1189 m (150 and 650 fm), although it expends ~85% of its effort between 457 and 823 m (250 and 450 fm) (Saunders *et al.* 1994).

The seamount fishery was restricted to the months of April to November by fishing regulations (DFO 1992). The general decrease in CPUE on Bowie Seamount over a period of 7-8 months in 1992 (April-November) and over 4 months (August-November) in 1991 (Figure 14) suggested either that the sablefish population on Bowie Seamount was being depleted within the fishing season of any one year or that the availability of the fish changed during the year. In the absence of fishing in the ensuing months of December to May, the recruitment of sablefish allowed the population to replenish to some degree as evidenced by the higher CPUE in April. The increase in CPUE on Bowie Seamount during the summer (July and August) in 1991-1993 may also be indicative of recruitment or increased aggregation of sablefish on the seamount.

SABLEFISH RECRUITMENT TO SEAMOUNTS

The similarity in the large increase in CPUE observed on Cobb, Union, and Warwick Seamounts in 1990 in particular, followed by a large decrease in CPUE in 1991 (Figure 13), may be related to the source and strength of recruitment. In the first instance, all three of these seamounts are in southern waters off the coast of British Columbia, are relatively close together, and are in an area with numerous other smaller seamounts (Figure 1). In contrast, the peak in CPUE in 1990 was not observed on

Bowie Seamount (Figure 13). Unlike the other three major seamounts, Bowie Seamount is located in northern waters off the coast of British Columbia (Figure 1). The difference in the peak in CPUE on the seamounts in southern versus northern waters may be related to differences in recruitment between the two areas. Recently, Saunders *et al.* (1994) suggested that sablefish in waters off British Columbia are not a single coastwide stock. In particular, tagging data indicate that sablefish in northern and southern British Columbia (north and south of ~ 51° 15' N) should be treated as separate stocks as they draw on different recruitment pools (McFarlane and Saunders In prep.). The northern stock of sablefish relies primarily on recruitment of fish from the inshore waters of Hecate Strait whereas the southern stock is maintained primarily by recruitment from the inshore waters of the west coast of Vancouver Island (McFarlane and Saunders In prep.). It is possible that sablefish recruiting to Bowie Seamount come from the northern stock, and sablefish recruiting to Cobb, Union, and Warwick Seamounts originate from the southern stock.

The large increase in CPUE on Union, Cobb and Warwick Seamounts in 1990, but not Bowie Seamount, could therefore have been due to a strong year-class recruiting to the southern seamounts but not to the northern seamounts. McFarlane and Beamish (1983a,b) and Beamish and McFarlane (1988) observed that the commercial fishery for sablefish is supported by strong year-classes and that these year-classes are an important component of sablefish stocks (e.g., the 1977 year-class). The importance of strong year classes to demersal fish stocks on seamounts was also evident in the pelagic armorhead fishery. Sasaki (1986) suggested that there was recruitment of an extremely strong year-class of armorhead in 1972, as reflected in a ten-fold increase in CPUE in the 1972 fishery. Fishing-up of this year-class subsequently resulted in a decline in the CPUE (Sasaki 1986). The suggestion of a strong cohort recruiting to Cobb, Warwick and Union Seamounts in 1990 could be investigated further and possibly corroborated by ageing sablefish collected prior to and after the peak in CPUE. Although Kabata *et al.* (1988) and Whitaker and McFarlane (*In press*) have determined that sablefish recruit to the seamounts from the coastal stock, a detailed study of the release locations for any tagged sablefish recovered during the seamount fishery would determine the actual location of the recruitment to southern versus northern seamounts.

Alternatively, the trend in CPUE for Cobb and Warwick Seamounts may have been confounded by additional sablefish being taken by non-Canadian vessels because these seamounts are outside of Canada's 200-mile limit (Figure 1). It was impossible to assess the significance of any additional catch taken off these two seamounts because of the unavailability of non-Canadian catch data (pers. comm., Frank Shaw, NMFS, Seattle). However, this would not explain the peak in CPUE on Union Seamount, which is completely within the Canadian 200-mile limit.

BIOLOGICAL CHARACTERISTICS OF SABLEFISH ON SEAMOUNTS

The absence of juvenile sablefish from seamounts has been observed previously by Hughes (1981), Alton (1986), Kabata *et al.* (1988), and Whitaker and McFarlane (*In press*). Alton (1986) suggested that the biomass of sablefish on Alaskan seamounts came from the migration of older individuals from continental slope areas. Based on tag recoveries from seamounts in the Gulf of Alaska and the northeast Pacific Ocean, Parks and Shaw (1993) also concluded that sablefish populations on seamounts were maintained by fish moving from slope areas. Alton (1986) has suggested that juvenile sablefish recruit to the deeper waters of the continental slope when 3-yr or 4-yr old, but that most of the sablefish recruiting to the seamounts are age 5 and older. Kabata *et al.* (1988) and Whitaker and McFarlane (*In press*) have also observed an absence of sablefish less than 3 yr old on the seamounts. However, from parasite loadings on fish captured on the seamounts versus on the slope, Kabata *et al.* (1988) and Whitaker and McFarlane (*In press*) determined that sablefish recruiting to the seamounts were less than 5-yr old: the majority being 3+- and 4+- yr fish.

The skewed sex ratios of catches on the seamounts, which were biased towards males (Tables 8, 9), have also been observed on seamounts in Alaska (Hughes 1981). Parks and Shaw (1993) also observed that tagged sablefish (U.S. tags) recovered from Bowie Seamount were 68% males. This is in contrast to the commercial fishery for sablefish on the slope in which the sex ratio is either equal or biased towards females in the catch (McFarlane and Beamish 1983a).

The sex ratio of the seamount catch may have been influenced by the depth of capture. On Bowie Seamount, the majority of fishing sets were biased towards males in the catch regardless of the depth of the set (50%=0.78 radians) (Figure 24). The strength of the bias was related to depth, however, and the proportion of males in the catch was greatest at mid-depths of ~600-900 m, which was also the depth range most frequently fished. The proportion of females in the catch appeared to increase at depths >900 m (Figure 24). This was consistent with exploratory trap fishing off the west coast of the Queen Charlotte Islands where more females than males were captured in deeper water (Beamish *et al.* 1979).

Alton (1986) proposed that sablefish populations on seamounts in the Gulf of Alaska are maintained by mature fish migrating from slope areas. The fish supposedly travel at intermediate depths because the seamount and slope areas are separated by abyssal depths (>3000 m) (Alton 1986) and sablefish abundance decreases at depths >1000-1500 m (Alton 1972). It is possible, however, that sablefish do migrate at great depths because Beamish *et al.* (1979) have trapped sablefish at depths of 2740 m. However, 92% of the sablefish sampled from their deep-water trapping study were females, indicating that males tend to occur in shallower water than females. To date, the presence of a preponderance of male sablefish on the seamounts and their mode of migration to the seamounts in the northeastern Pacific Ocean is not well understood.

FUTURE RESEARCH

In the presence of fishing pressure, seamount populations of sablefish may be dependent on strong year-classes for sustainability. Ageing samples of fish obtained in the 1990 fishery and the pre- and post-1990 fisheries (e.g., 1989 and 1991) would help to determine the importance of any one cohort recruiting to the fishery. Given that seamounts are relatively small, discrete fishing areas that may be prone to localised depletion, it should be possible to estimate the abundance of sablefish on some of the major seamounts by using a depletion estimator (Hilborn and Walters 1992, Ralston and Tagami 1992). In addition, tags were returned from sablefish captured on the northeastern Pacific Ocean seamounts during the experimental fishery of 1989-1993. This data base has been partially analysed in Whitaker and McFarlane (*In press*) with respect to size and age of recruitment of sablefish to seamounts, and by Parks and Shaw (1993) with respect to movements of tagged sablefish. It would be useful to analyse these mark-recapture data for their release location (i.e., the north or the south) in relation to the recapture location on the seamounts.

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Table 1. Location and approximate depth and dimensions of seamounts fished in the Canadian trap-fishery 1983-1993.

SEAMOUNT	LOCATION		Minimum Depth (m)[a] (Summit)	Maximum Depth (m)[a] (Base)	Dimensions (nm)[a,b]	
	Latitude	Longitude			Length	Width
Bowie	53° 19'	135° 40'	14-66	2531-2970	16	8
Brown Bear	46° 03'	130° 30'	475[c]		12[c]	7[c]
Cobb	46° 45'	130° 50'	24-143	1957-2789	15	12
Cowie	54° 08'	149° 22'			24[d]	10[d]
Dellwood	50° 42'	130° 54'	543-1756	2048-2679	20	6
Eickelberg	48° 30'	133° 07'	790-1809	2634-3320	17	7
Far (=West) Cobb	46° 42'	131° 20'	369-1200	2528-3278	14	9
Heck	48° 26'	129° 25'	1046-1721	2304-2396	8	6
Hodgkins	53° 30'	136° 05'	790-1756	2176-3365	21	8
Murray	53° 57'	148° 31'			30[d]	14[d]
Pratt	56° 14'	142° 28'	700-824[e]		33[d]	11[d]
Surveyor	56° 01'	144° 24'	366-824[e]		19[d]	11[d]
Union	49° 35'	132° 47'	293-1251	2272-3263	21	7
Warwick	48° 03'	132° 44'	468-1701	2085-2597	20	8
Unnamed ("XX")	48° 41'	131° 18'	1729	2184-2876		
Unnamed ("XY")	46° 19'	130° 35'	611-1664	2740	17	10

[a] Depths determined from Canadian Hydrographic Chart L/C 3000 (1994).
[b] Dimensions of seamounts at 1000 fm (=1829 m) isobath from Canadian Hydrographic Chart L/C 3000 (1994).
[c] From Budinger (1967).
[d] Estimates from Figure 1 (2000 m isobath) in Hughes (1981).
[e] Alton (1986).

Table 2. Summary of trap-fishing trips for sablefish to northeastern Pacific Ocean seamounts and type and number of biological samples of sablefish collected from trips, 1983-1993 (L/S=length and sex; L/S/A=length, sex, and age; L/S/A/STOM=length, sex, age and stomachs).

YEAR	DATE	VESSEL	TRIP REPORT NO.[a]	FILE NO.[b]	SEAMOUNT	TYPE OF SAMPLE: L/S NO. SAMP.	L/S NO. FISH	L/S/A NO. SAMP.	L/S/A NO. FISH	L/S/A/STOM NO. SAMP.	L/S/A/STOM NO. FISH
1983	Apr 3-Apr 17	Ocean Pearl		83001	Cobb	0	0	1	313[c]	0	0
					Dellwood	0	0	0	0	0	0
					Eickelberg	0	0	0	0	0	0
					Union	0	0	2	961[c]	0	0
1985[d]	Aug 23-Sep 27	La Porsche		85001	Bowie	5	1156	1	299	0	0
					Cobb	4	496	1	299	1	50
					Eickelberg	1	26	0	0	0	0
					Hodgkins	0	0	1	292	0	0
					Union	2	381	3	646	0	0
					Warwick	2	381	2	306	0	0
1987[d]	Jan 22-Feb 10	La Porsche		87001	Bowie	1	152	2	309	0	0
					Dellwood	1	215	3	307	0	0
1988	May 14-May 30	Ocean Pearl		88001	Brown Bear	0	0	0	0	0	0
					Cobb	0	0	0	0	0	0
					Surveyor	0	0	0	0	0	0
					Warwick	0	0	0	0	0	0
1988	Jun 11-Jul 16	Viking Sunrise		88002	Bowie	0	0	1	220[c]	1	59[c]
1988	Sep 13-Sep 21	La Porsche		88003	Union	0	0	1	277[c]	0	0

Table 2 (Cont'd). Summary of trap-fishing trips for sablefish to northeastern Pacific Ocean seamounts and type and number of biological samples of sablefish collected from trips, 1983-1993 (L/S=length and sex; L/S/A=length, sex, and age; L/S/A/STOM=length, sex, age and stomachs).

YEAR	DATE	VESSEL	TRIP REPORT NO.[a]	FILE NO.[b]	SEAMOUNT	TYPE OF SAMPLE: L/S		L/S/A		L/S/A/STOM	
						NO. SAMP.	NO. FISH	NO. SAMP.	NO. FISH	NO. SAMP.	NO. FISH
1989	Jun 1-Jul 19	Viking Sunrise		89001	Bowie	3	866	1	300[c]	0	0[c]
1989	Aug 8-Sep 7	Transpacific No.1		89002	Union	1	214	1	290	0	0
					Warwick	1	169	1	200	1	38
1989	Aug 26-Sep 18	Pacific Titan		89003	Cobb	2	187	0	0	1	50[e]
					Warwick	0	0	0	0	1	50[e]
1990	Jun 3-Jul 4	Jeanna Marie		90001	Cobb	1	299	0	0	0	0
					Far Cobb	0	0	1	234	0	0
					Cobb (South)	0	0	0	0	0	0
					Dellwood	0	0	0	0	0	0
					Eickelberg	0	0	0	0	0	0
					Warwick	0	0	1	154	0	0
					Union	0	0	1	200	0	0
1990	May 26-Jul 7	Viking Sunrise		90002	Bowie	3	594	1	196	0	0
1991	Mar 31-May 1	Nopsa	S-NOP-1-2	91001	Bowie	7	874	2	341	0	0

Table 2 (Cont'd). Summary of trap-fishing trips for sablefish to northeastern Pacific Ocean seamounts and type and number of biological samples of sablefish collected from trips, 1983-1993 (L/S=length and sex; L/S/A=length, sex, and age; L/S/A/STOM=length, sex, age and stomachs).

YEAR	DATE	VESSEL	TRIP REPORT NO.[a]	FILE NO.[b]	SEAMOUNT	TYPE OF SAMPLE: L/S		L/S/A		L/S/A/STOM	
						NO. SAMP.	NO. FISH	NO. SAMP.	NO. FISH	NO. SAMP.	NO. FISH
1991	Mar 29-Apr 16	Jeanna Marie	S-JNM-1-1	91002	Brown Bear	2	295	1	100	0	0
					Cobb	2	259	2	175	0	0
					Far Cobb	2	180	1	121	0	0
					Warwick	1	148	1	105	0	0
1991	Apr 8-May 10	La Porsche	S-LAP-1-3	91003	Brown Bear	2	231	3	305	0	0
					Cobb	3	466	2	300	0	0
					Warwick	1	98	2	261	0	0
1991	May 3-Jun 4	Viking Sunrise	S-SUN-1-5	91004	Bowie	10	1382	2	318	0	0
1991	Jun 6-Jul 5	Lana Janine	S-LNJ-1-6	91005	Bowie	9	1025	2	275	0	0
1991	Jun 4-Jun 8	Jeanna Marie	S-JNM-2-4	91006	Cobb	0	0	0	0	0	0
1991	Jul 7-Aug 10	Viking Sunrise	S-SUN-2-22	91021	Bowie	8	906	2	303	0	0
1991	Jul 30-Aug 20	La Porsche	S-LAP-2-28	91029	Union	1	149	2	235	0	0
					Cobb	4	411	2	284	0	0
					Brown Bear	2	166	2	185	0	0
1991	Aug 13-Aug 25	Viking Sunrise	S-SUN-3-31	91039	Bowie	3	504	2	281	0	0

Table 2 (Cont'd). Summary of trap-fishing trips for sablefish to northeastern Pacific Ocean seamounts and type and number of biological samples of sablefish collected from trips, 1983-1993 (L/S=length and sex; L/S/A=length, sex, and age; L/S/A/STOM=length, sex, age and stomachs).

YEAR	DATE	VESSEL	TRIP REPORT NO.[a]	FILE NO.[b]	SEAMOUNT	TYPE OF SAMPLE: L/S		L/S/A		L/S/A/STOM	
						NO. SAMP.	NO. FISH	NO. SAMP.	NO. FISH	NO. SAMP.	NO. FISH
1991	Aug 28-Oct 10	Viking Sunrise	S-SUN-4-50	91046	Bowie	10	1073	0	0	0	0
					Hodgkins	6	512	1	85	0	0
1991	Sep 3-Sep 24	Nopsa	S-NOP-2-47	91047	Union	2	206	1	154	0	0
					Cobb	3	312	2	311	0	0
1991	Oct 5-Nov 5	La Porsche	S-LAP-4-51	91054	Warwick	0	0	2	231	0	0
					Eickelberg	1	155	2	241	0	0
					Union	1	59	2	242	0	0
					Hodgkins	0	0	3	124	0	0
					Bowie	2	271	3	314	0	0
1992	Apr 8-May 4	La Porsche	S-LAP-1-1	92003	Bowie	7	913	2	288	0	0
1992	Apr 16-May 6	Viking Star	S-VST-1-2	92004	Union	1	93	1	130	2	98
					Warwick	1	86	3	233	10	551[f]
					Cobb	1	94	3	184	4	166[f]
1992	Apr 24-May 6	Transpacific #1	S-TCP-1-3	92008	Union	6	833	2	292	0	0
1992	May 10-May 21	Nopsa	S-NOP-1-5	92010	Surveyor	0	0	1	39	1	50
					Pratt	0	0	0	0	0	0
1992	May 9-May 18	Transpacific #1	S-TCP-2-4	92011	Pratt	0	0	0	0	1	25

Table 2 (Cont'd). Summary of trap-fishing trips for sablefish to northeastern Pacific Ocean seamounts and type and number of biological samples of sablefish collected from trips, 1983-1993 (L/S=length and sex; L/S/A=length, sex, and age; L/S/A/STOM=length, sex, age and stomachs).

YEAR	DATE	VESSEL	TRIP REPORT NO.[a]	FILE NO.[b]	SEAMOUNT	TYPE OF SAMPLE: L/S		L/S/A		L/S/A/STOM	
						NO. SAMP.	NO. FISH	NO. SAMP.	NO. FISH	NO. SAMP.	NO. FISH
1992	May 19-May 29	La Porsche	S-LAP-2-7	92012	Bowie	3	544	3	390	9	477[f]
	May 29-Jun 1	La Porsche	S-LAP-3-8[g]	92018	Bowie	0	0	0	0	0	0
1992	May 23-Jun 7	Nopsa	S-NOP-2-9	92016	Warwick	4	496	1	109	1	50
					Brown Bear	1	94	1	106	0	0
					XX	0	0	1	94	0	0
					Cobb	2	207	1	117	1	50
1992	May 28-Jul 2	Star Wars	S-SWR-1-12	92017	Bowie	19	2396	3	403	0	0
1992	May 30-Jun 30	Westerly Wind	S-WWN-1-10	92019	Union	2	239	1	40	0	0
					Eickelberg	3	237	2	90	0	0
					Warwick	9	1090	2	135	0	0
1992	Jun 13-Jul 3	Nopsa	S-NOP-3-11	92029	Cobb	0	0	0	0	0	0
					XX	2	219	2	187	1	50
					Brown Bear	8	1067	2	248	1	39
1992	Jul 2-Aug 2	Viking Sunrise	S-SUN-1-16	92036	Bowie	22	5184	4	599	53	2065[f]
					Hodgkins	0	0	2	279	2	65[f]
1992	Jul 2-Jul 15	La Porsche	S-LAP-4-14	92037	Murray	2	210	1	160	4	200[f]
					Cowie	0	0	1	137	2	100[f]

Table 2 (Cont'd). Summary of trap-fishing trips for sablefish to northeastern Pacific Ocean seamounts and type and number of biological samples of sablefish collected from trips, 1983-1993 (L/S=length and sex; L/S/A=length, sex, and age; L/S/A/STOM=length, sex, age and stomachs).

YEAR	DATE	VESSEL	TRIP REPORT NO.[a]	FILE NO.[b]	SEAMOUNT	TYPE OF SAMPLE: L/S NO. SAMP.	L/S NO. FISH	L/S/A NO. SAMP.	L/S/A NO. FISH	L/S/A/STOM NO. SAMP.	L/S/A/STOM NO. FISH
1992	Jul 7-Jul 25	Nopsa	S-NOP-4-13	92038	Brown Bear	6	1168	2	210	1	50
					XX	4	557	2	188	1	50
					Cobb	0	0	1	106	1	36
					XY	1	210	0	0	1	50
1992	Aug 1-Aug 18	Nopsa	S-NOP-5-18	92047	Cobb	0	0	0	0	0	0
					Warwick	2	380	2	268	1	50
					Eickelberg	1	105	0	0	1	50
					Brown Bear	5	775	2	291	1	50
1992	Jul 30-Sep 4	Pacific Prowler	S-PPR-1-21	92048	Bowie	19	1947	2	264	0	0
1992	Aug 22-Sep 4	Westerly Wind	S-WWN-2-22	92051	Heck	2	8	0	0	0	0
					Cobb	1	104	1	51	0	0
					Warwick	3	278	1	49	0	0
1992	Aug 29-Sep 19	Viking Sunrise	S-SUN-2-24	92060	Bowie	7	1030	3	338	20	827[f]
1992	Sep 30-Oct 10	Nopsa	S-NOP-6-25	92065	Bowie	4	399	1	104	0	0
1993	Mar 31-Apr 14	Star Wars II	S-SWR-1-04	93004	Bowie	7	812	2	274	3	122[f]
1993	Apr 23-Apr 29	Nopsa	S-NOP-2-06	93006	Union	1	94	1	100	0	0

Table 2 (Cont'd). Summary of trap-fishing trips for sablefish to northeastern Pacific Ocean seamounts and type and number of biological samples of sablefish collected from trips, 1983-1993 (L/S=length and sex; L/S/A=length, sex, and age; L/S/A/STOM=length, sex, age and stomachs).

YEAR	DATE	VESSEL	TRIP REPORT NO.[a]	FILE NO.[b]	SEAMOUNT	TYPE OF SAMPLE: L/S NO. SAMP.	L/S NO. FISH	L/S/A NO. SAMP.	L/S/A NO. FISH	L/S/A/STOM NO. SAMP.	L/S/A/STOM NO. FISH
1993	Apr 29-May 29	Westerly Wind	S-WWN-1-09	93007	Bowie	9	1457	3	349	0	0
1993	Jun 3-Jun 20	Star Wars II	S-SWR-2-10	93010	Bowie	6	358	2	354	0	0
					Union	1	67	2	278	0	0
1993	Jul 10-Aug 13	Westerly Wind	S-WWN-2-11	93011	Bowie	8	909	3	439	0	0
					Union	2	190	2	233	0	0
					Warwick	2	291	2	239	0	0
1993	Aug 9-Aug 26	Viking Star	S-VST-1-12	93025	Bowie	11	616	2	202	0	0

[a] Trip report numbers were assigned by Archipelago Marine Research, 1991-1993.
[b] File numbers prior to 1991 were assigned by Department of Fisheries & Oceans; file numbers from 1991-1993 were assigned by Archipelago Marine Research.
[c] Frozen in the round, head on, for delivery to port observers.
[d] No catch data available for this trip.
[e] Age and stomach sample only.
[f] Length, age, and stomach sample only.
[g] Part II of trip S-LAP-2-7.

Table 3. Total annual catch, annual mean CPUE (±SE), and monthly mean CPUE (±SE) for sablefish trapped by Canadian vessels on Bowie Seamount in the northeastern Pacific Ocean, 1985-1993.

YEAR	CATCH (t)	MONTH	CPUE (kg/trap)	SE (kg/trap)	NO. SETS
1985		(not available)			
1987	88.0	annual	17.58	1.09	75
		05	17.56	1.14	48
		06	17.63	2.31	27
1988	135.8	annual	30.61	1.65	57
		06	38.33	2.31	25
		07	24.58	1.68	32
1989	107.9	annual	19.94	1.78	36
		06	23.81	2.17	24
		07	12.21	1.53	12
1990	112.9	annual	16.52	0.72	84
		05	17.92	1.52	17
		06	16.16	0.81	67
1991	303.2	annual	10.16	0.40	303
		04	10.53	0.76	54
		05	8.48	0.77	64
		06	12.38	0.75	67
		07	10.50	1.56	34
		08	16.20	2.08	21
		09	8.11	1.13	30
		10	6.22	0.75	29
		11	4.02	1.88	4
1992	195.6	annual	9.08	0.45	272
		04	20.89	2.51	24
		05	9.71	0.84	21
		06	7.10	0.51	70
		07	11.22	0.80	73
		08	5.08	0.57	40
		09	4.72	0.98	22
		10	6.37	0.66	22

Table 3 (Cont'd). Total annual catch, annual mean CPUE (±SE), and monthly mean CPUE (±SE) for sablefish trapped by Canadian vessels on Bowie Seamount in the northeastern Pacific Ocean, 1985-1993.

YEAR	CATCH (t)	MONTH	CPUE (kg/trap)	SE (kg/trap)	NO. SETS
1993	43.2	annual	4.84	0.35	130
		04	4.90	0.89	22
		05	6.97	0.54	36
		06	0.92	0.13	22
		07	7.70	1.05	21
		08	3.03	0.31	29

Table 4. Total annual catch, annual mean CPUE (±SE), and monthly mean CPUE (±SE) for sablefish trapped by Canadian vessels on Cobb Seamount in the northeastern Pacific Ocean, 1983-1992.

YEAR	CATCH (t)	MONTH	CPUE (kg/trap)	SE (kg/trap)	NO. SETS
1983	36.9	04	22.40	1.84	26
1985		(not available)			
1988	10.3	05	5.38	0.80	32
1989	10.3	annual	8.40	1.82	13
		08	9.68	2.37	9
		09	5.52	2.26	4
1990	33.7	06	13.28	0.91	25
1991	30.2	annual	5.56	0.39	66
		04	5.77	0.59	37
		08	5.64	0.60	20
		09	4.50	0.73	9
1992	11.4	annual	4.43	0.76	39
		04	3.16	0.81	10
		05	1.56	0.33	8
		06	8.21	1.74	13
		07	3.64	1.05	4
		08	1.90	0.50	4

Table 5. Total annual catch, annual mean CPUE (±SE), and monthly mean CPUE (±SE) for sablefish trapped by Canadian vessels on Union Seamount in the northeastern Pacific Ocean, 1983-1993.

YEAR	CATCH (t)	MONTH	CPUE (kg/trap)	SE (kg/trap)	NO. SETS
1983	18.7	04	17.18	3.43	11
1985		(not available)			
1988	6.2	09	8.09	0.98	12
1989	26.0	08	11.41	1.20	26
1990	7.3	06	12.59	1.89	6
1991	19.3	annual	7.08	0.71	41
		05	13.09	1.00	8
		08	7.60	1.61	8
		09	4.65	0.74	17
		10	5.72	1.13	8
1992	14.8	annual	4.45	0.43	39
		04	4.40	0.50	24
		05	4.32	0.80	9
		06	4.82	1.74	6
1993	10.0	annual	5.69	0.76	30
		04	6.37	1.38	8
		06	2.69	0.37	9
		08	7.34	1.30	13

Table 6. Total annual catch, annual mean CPUE (±SE), and monthly mean CPUE (±SE) for sablefish trapped by Canadian vessels on Warwick Seamount in the northeastern Pacific Ocean, 1985-1993.

YEAR	CATCH (t)	MONTH	CPUE (kg/trap)	SE (kg/trap)	NO. SETS
1985		(not available)			
1988	3.0	05	4.95	1.33	10
1989	17.6	09	8.89	1.14	19
1990	15.8	06	16.60	2.25	10
1991	11.4	annual	6.37	0.49	25
		04	7.80	1.22	7
		05	5.75	0.44	10
		10	5.91	0.88	8
1992	26.1	annual	6.59	0.59	54
		04	3.96	0.60	17
		05	5.38	1.15	9
		06	7.98	0.98	15
		08	10.86	1.55	10
		09	3.97	1.98	3
1993	4.3	08	6.26	0.83	13

Table 7. Total annual catch, annual mean CPUE (±SE), and monthly mean CPUE (±SE) for sablefish trapped by Canadian vessels on minor seamounts in the northeastern Pacific Ocean, 1983-1993.

SEAMOUNT	YEAR	CATCH (t)	MONTH	CPUE (kg/trap)	SE (kg/trap)	NO. SETS
Brown Bear	1988	4.8	05	5.70	0.83	14
	1991	20.9	annual	5.61	0.44	51
			04	5.99	0.50	40
			08	4.22	0.81	11
	1992	38.4	annual	9.48	0.66	73
			05	7.20	-	1
			06	11.32	1.03	37
			07	6.95	0.82	18
			08	8.29	1.18	17
Cowie	1992	1.7	07	9.75	2.78	3
Dellwood	1983	9.0	04	11.53	2.68	13
	1987		(not available)			
	1990	0.09	06	11.38	2.57	8
Eickelberg	1983	2.8	08	5.86	0.65	8
	1985		(not available)			
	1990	2.1	06	12.18	0.78	3
	1991	3.0	10	4.49	0.85	9
	1992	2.2	annual	4.69	1.18	8
			06	4.20	1.24	7
			08	8.16	-	1
Far Cobb	1990	17.4	06	16.42	1.84	14
	1991	1.9	04	4.55	1.31	6
Heck	1992	0.02	08	0.06	1.24	2
Hodgkins	1985		(not available)			
	1991	5.5	annual	4.73	1.55	11
			09	6.48	2.21	7
			10	1.71	0.45	4
	1992	2.8	07	8.42	1.33	6
Murray	1992	3.0	07	6.78	1.24	8

Table 7 (Cont'd). Total annual catch, annual mean CPUE (±SE), and monthly mean CPUE (±SE) for sablefish trapped by Canadian vessels on minor seamounts in the northeastern Pacific Ocean, 1983-1993.

SEAMOUNT	YEAR	CATCH (t)	MONTH	CPUE (kg/trap)	SE (kg/trap)	NO. SETS
Pratt	1992	0.3	05	0.78	0.24	6
Surveyor	1988	1.9	05	3.18	0.41	10
	1992	0.4	05	0.87	0.23	6
XX	1992	21.4	annual	10.57	0.88	33
			05	15.96	-	1
			06	10.28	1.24	16
			07	10.52	1.31	16
XY	1992	1.7	07	8.41	2.55	4

Table 8. Mean fork lengths (±SE) of male and female sablefish sampled from major seamounts in the northeastern Pacific Ocean, 1983-1993. Deviation from a 1:1 sex ratio was indicated by $P \leq 0.05$; NS=no significant deviation from a 1:1 ratio; M=sex ratio biased towards males, and F=sex ratio biased towards females.

Seamount	Year	Males			Females			Sex Ratio		
		Mean	SE	n	Mean	SE	n	χ_c^2	P	Bias
Bowie	1985	61.90	0.14	987	71.74	0.24	468	184.41	0.001	M
	1987	61.27	0.28	224	70.10	0.33	234	0.18	0.50	NS
	1988	60.13	0.19	222	66.61	0.63	44	117.78	0.001	M
	1989	61.46	0.10	881	68.67	0.26	284	304.91	0.001	M
	1990	62.42	0.19	414	70.74	0.26	355	4.37	0.05	M
	1991	63.75	0.06	3315	70.34	0.10	2720	58.46	0.001	M
	1992	63.47	0.04	7956	71.30	0.07	3829	1444.54	0.001	M
	1993	63.19	0.07	2764	71.70	0.12	1388	455.35	0.001	M
Cobb	1983	60.35	0.33	207	70.43	0.80	62	85.93	0.001	M
	1985	60.96	0.21	618	71.13	0.47	227	180.00	0.001	M
	1989	61.04	0.36	136	66.90	0.80	51	37.73	0.001	M
	1990	60.58	0.31	249	67.84	1.09	50	131.12	0.001	M
	1991	61.56	0.16	1000	68.79	0.29	448	209.67	0.001	M
	1992	62.45	0.27	289	70.90	0.51	112	77.25	0.001	M
Union	1983	61.15	0.16	844	71.17	0.27	449	159.36	0.001	M
	1985	61.10	0.15	843	70.88	0.38	184	421.58	0.001	M
	1988	58.87	0.18	331	64.79	0.74	34	240.04	0.001	M
	1989	63.58	0.25	319	70.93	0.35	175	41.39	0.001	M
	1990	62.37	0.38	138	72.03	0.67	62	28.12	0.001	M

Table 8 (Cont'd). Mean fork lengths (±SE) of male and female sablefish sampled from major seamounts in the northeastern Pacific Ocean, 1983-1993. Deviation from a 1:1 sex ratio was indicated by $P \leq 0.05$; NS=no significant deviation from a 1:1 ratio; M=sex ratio biased towards males, and F=sex ratio biased towards females.

Seamount	Year	Males			Females			Sex Ratio		
		Mean	SE	n	Mean	SE	n	χ_c^2	P	Bias
Union	1991	63.66	0.26	292	70.77	0.52	122	68.99	0.001	M
	1992	62.63	0.14	855	71.37	0.32	310	254.02	0.001	M
	1993	63.73	0.27	232	72.56	0.48	119	35.74	0.001	M
Warwick	1985	62.61	0.20	521	70.24	0.42	166	182.41	0.001	M
	1989	62.49	0.20	306	70.04	0.53	100	103.51	0.001	M
	1990	63.77	0.39	121	71.24	0.88	33	49.15	0.001	M
	1991	63.83	0.34	144	71.72	0.55	102	6.83	0.010	M
	1992	63.21	0.10	1649	71.57	0.19	681	401.33	0.001	M
	1993	64.11	0.29	176	71.07	0.45	115	12.37	0.001	M

Table 9. Mean fork lengths (±SE) of male and female sablefish sampled from minor seamounts in the northeastern Pacific Ocean, 1983-1993. Deviation from a 1:1 sex ratio was indicated by $P \leq 0.05$; NS=no significant deviation from a 1:1 ratio; M=sex ratio biased towards males, and F=sex ratio biased towards females.

Seamount	Year	Males			Females			Sex Ratio		
		Mean	SE	n	Mean	SE	n	χ_c^2	P	Bias
Brown Bear	1991	62.33	0.26	380	70.11	0.39	312	6.49	0.025	M
	1992	61.70	0.10	2428	70.15	0.25	674	990.65	0.001	M
Cowie	1992	62.74	0.46	61	76.09	0.80	76	1.43	0.10	NS
Dellwood	1987	59.71	0.45	194	68.82	0.43	304	23.42	0.001	F
Eickelberg	1985	58.50	1.00	20	66.33	2.06	6	6.50	0.025	M
	1991	62.39	0.59	72	70.25	0.59	83	0.64	0.25	NS
	1992	62.62	0.30	216	70.02	0.53	126	23.16	0.001	M
Far Cobb	1990	63.75	0.39	159	71.07	0.81	55	49.57	0.001	M
	1991	62.04	0.48	119	67.21	0.90	61	18.05	0.001	M
Heck	1992	68.00	2.55	4	81.00	2.34	4	-	-	NS
Hodgkins	1985	61.01	0.29	192	69.60	0.67	100	28.36	0.001	M
	1991	65.61	0.31	321	70.66	0.34	191	32.50	0.001	M
	1992	62.36	0.28	187	70.90	0.53	90	33.27	0.001	M
Murray	1992	62.92	0.31	144	75.18	0.69	66	28.23	0.001	M

Table 9 (Cont'd). Mean fork lengths (±SE) of male and female sablefish sampled from minor seamounts in the northeastern Pacific Ocean, 1983-1993. Deviation from a 1:1 sex ratio was indicated by $P \leq 0.05$; NS=no significant deviation from a 1:1 ratio; M=sex ratio biased towards males, and F=sex ratio biased towards females.

Seamount	Year	Males			Females			Sex Ratio		
		Mean	SE	n	Mean	SE	n	χ_c^2	P	Bias
Pratt	1992	65.23	0.91	17	73.12	2.27	8	2.56	0.10	NS
Surveyor	1992	64.62	0.64	37	74.85	0.93	52	2.20	0.10	NS
XX	1992	63.38	0.18	524	70.50	0.32	252	94.64	0.001	M
XY	1992	62.03	0.38	175	67.94	0.92	35	92.00	0.001	M

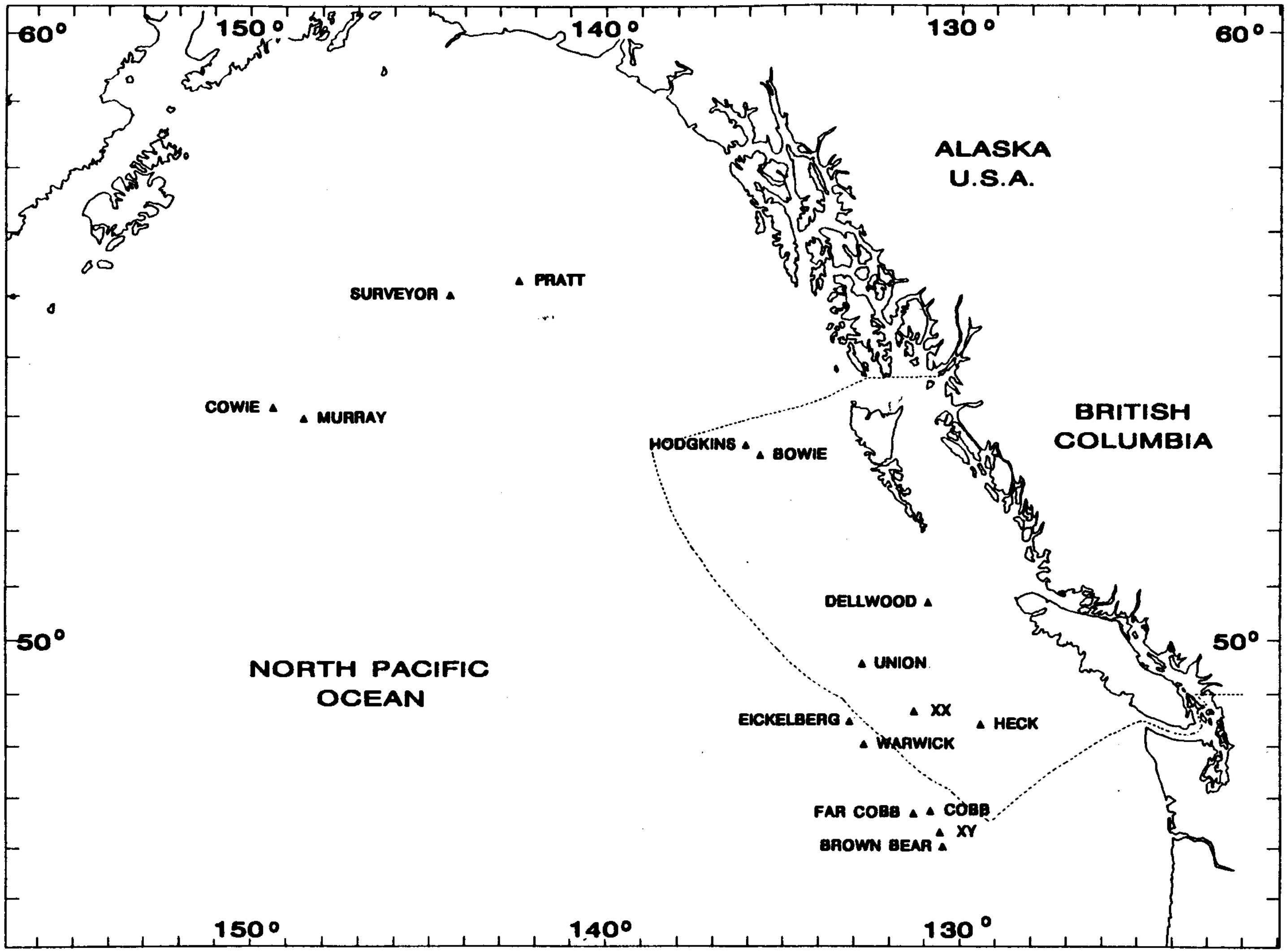

Figure 1. Location of seamounts in the northeastern Pacific Ocean fished for sablefish using traps, 1983-1993. Dashed line represents Canada's 200-nm Fishery Conservation Zone.

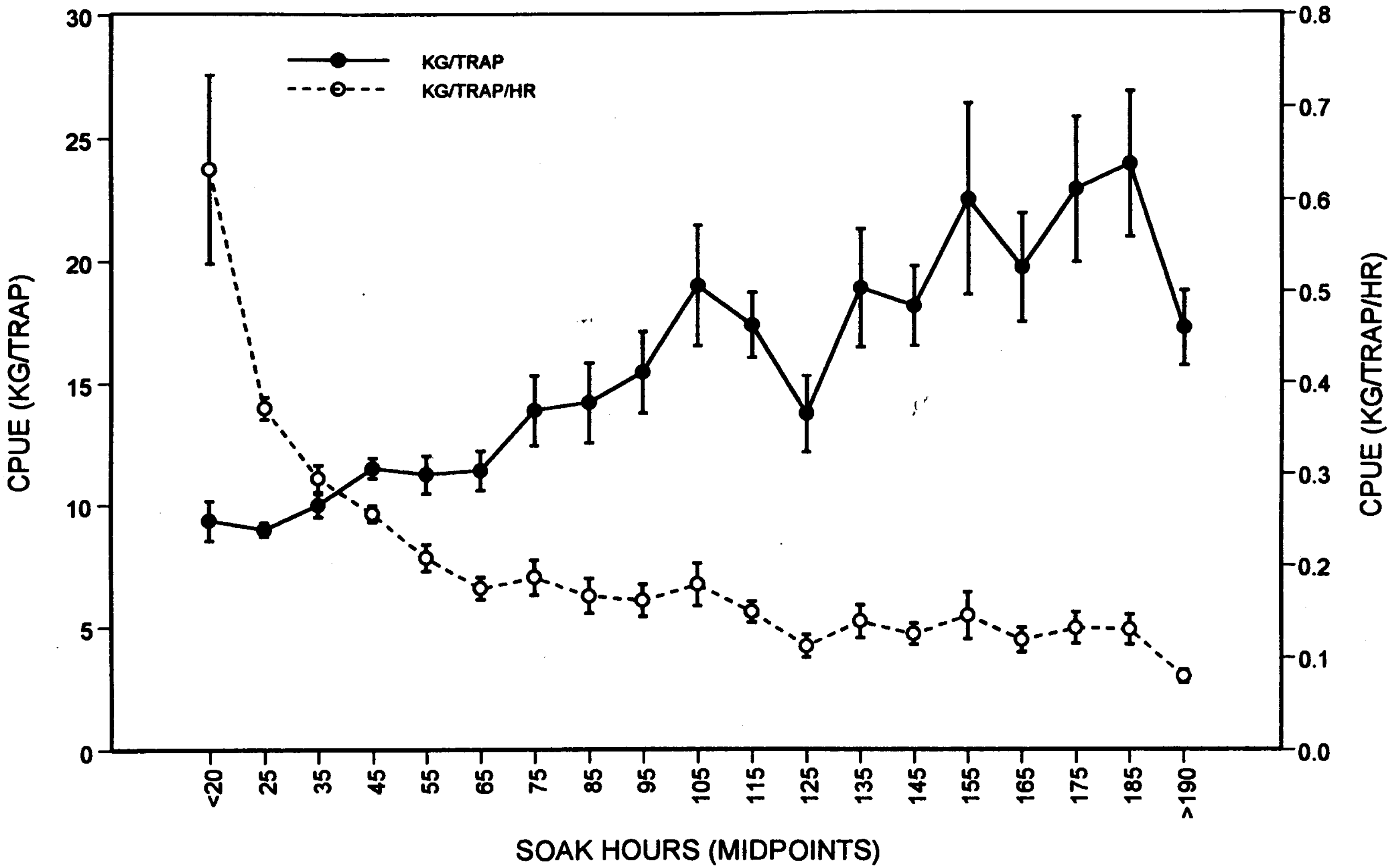

Figure 2. Mean CPUE (±) in kg/trap and kg/trap/hr as a function of soak time for the sablefish trap-fishery on seamounts in the northeastern Pacific Ocean, 1983-1993.

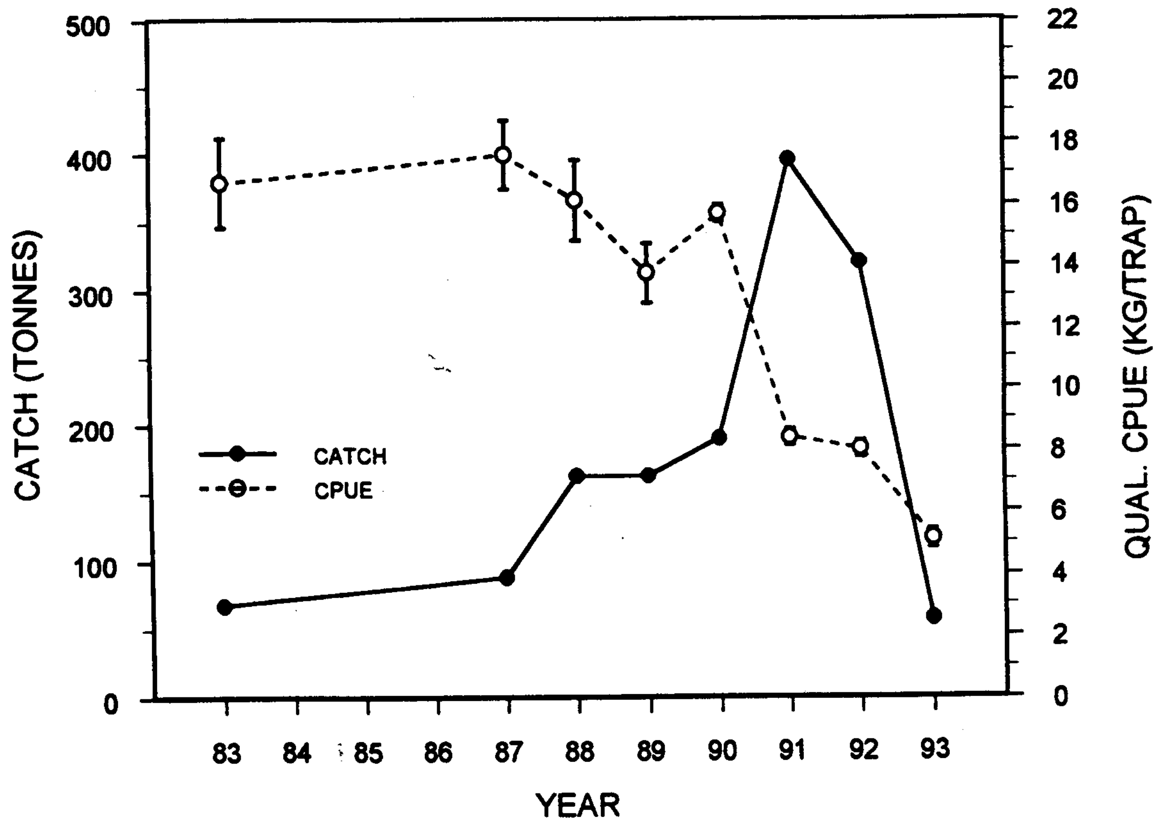

Figure 3. Total annual catch and annual mean CPUE (kg/trap) for sets with 20-70 hr soaks for the sablefish trap-fishery on northeastern Pacific Ocean seamounts.

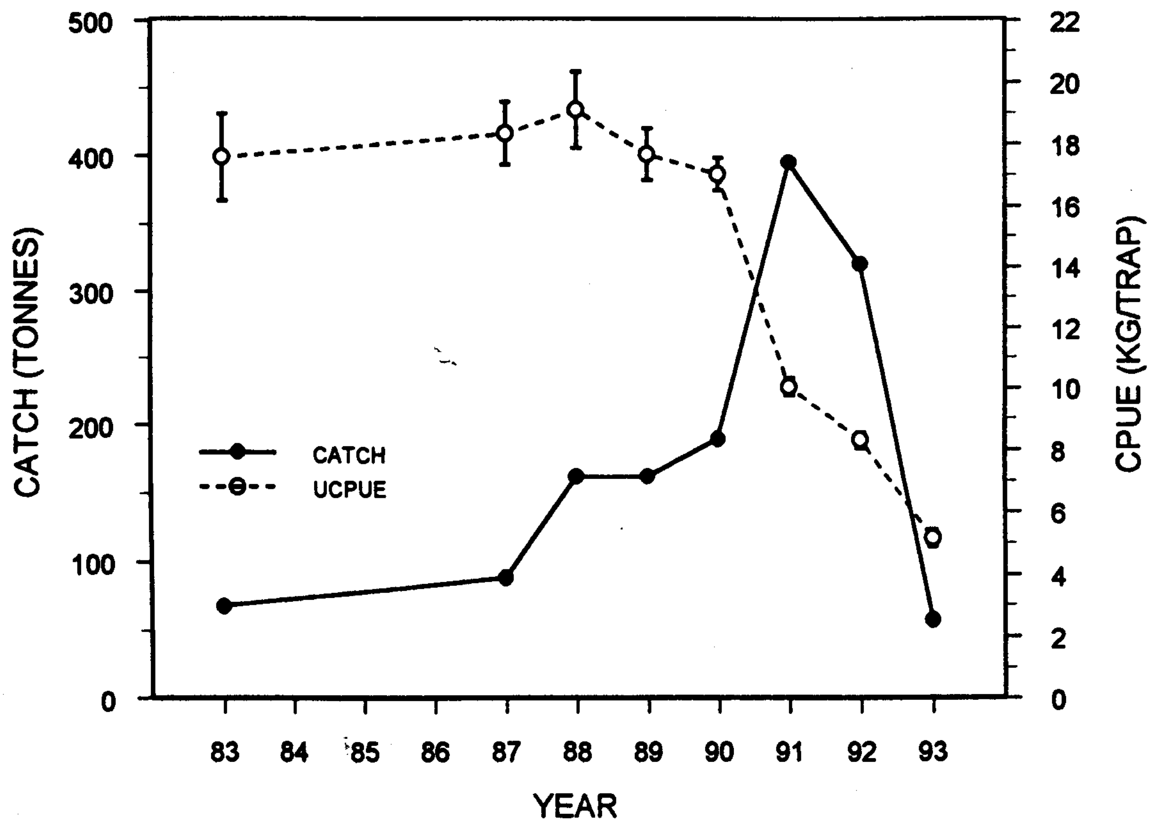

Figure 4. Total annual catch and annual mean CPUE (kg/trap) for all sets in the sablefish trap-fishery on northeastern Pacific Ocean seamounts.

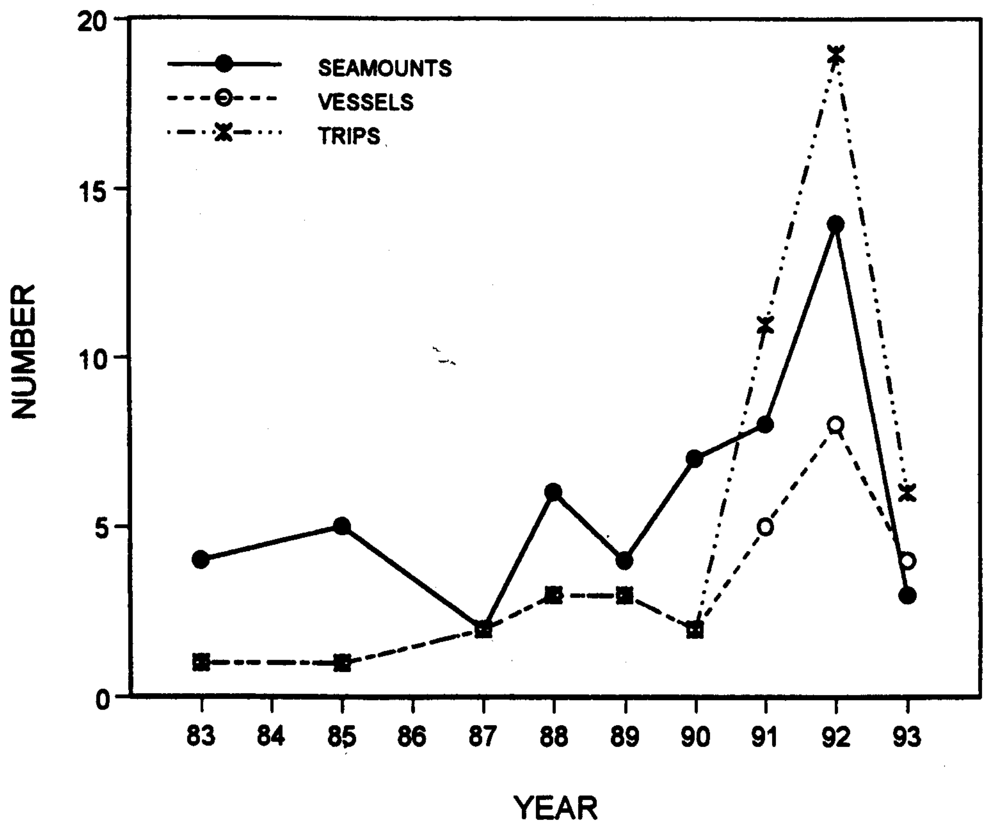

Figure 5. Annual number of seamounts fished, annual number of individual vessels involved in the seamount fishery, and number of annual trips to seamounts in the northeastern Pacific Ocean.

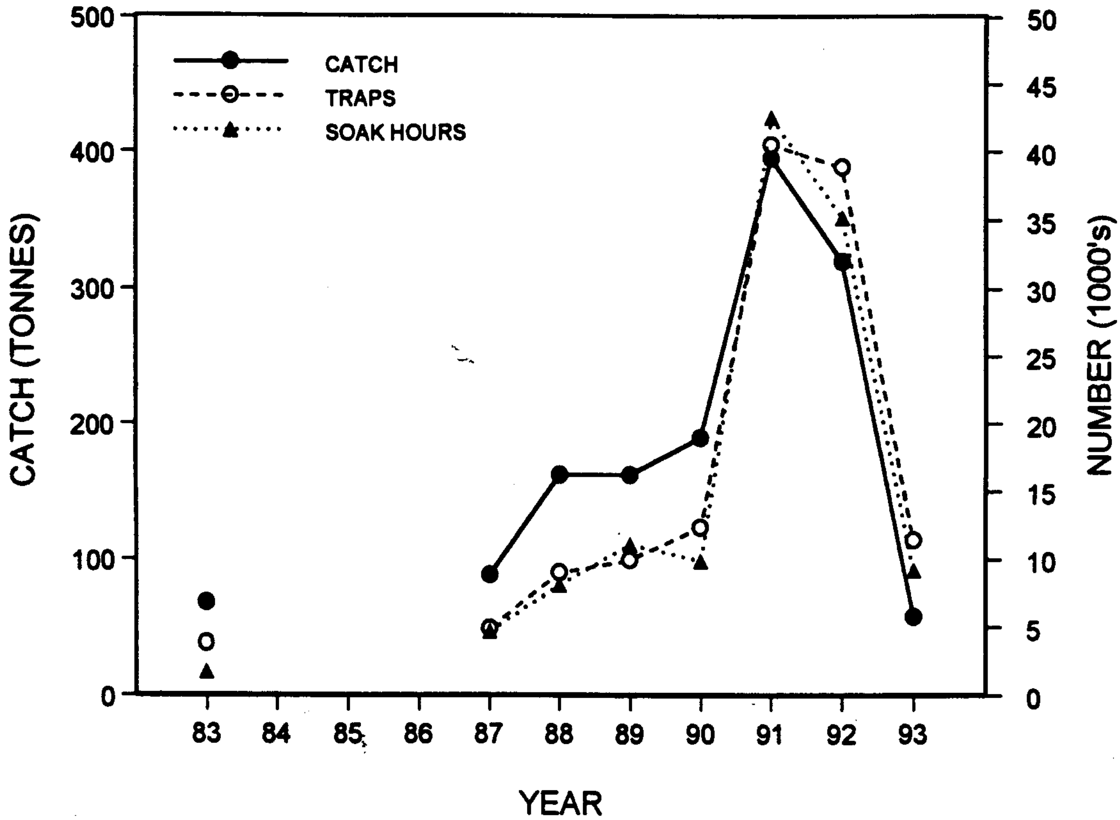

Figure 6. Annual catch of sablefish, annual number of traps deployed, and annual number of soak hours for the trap-fishery on northeastern Pacific Ocean seamounts.

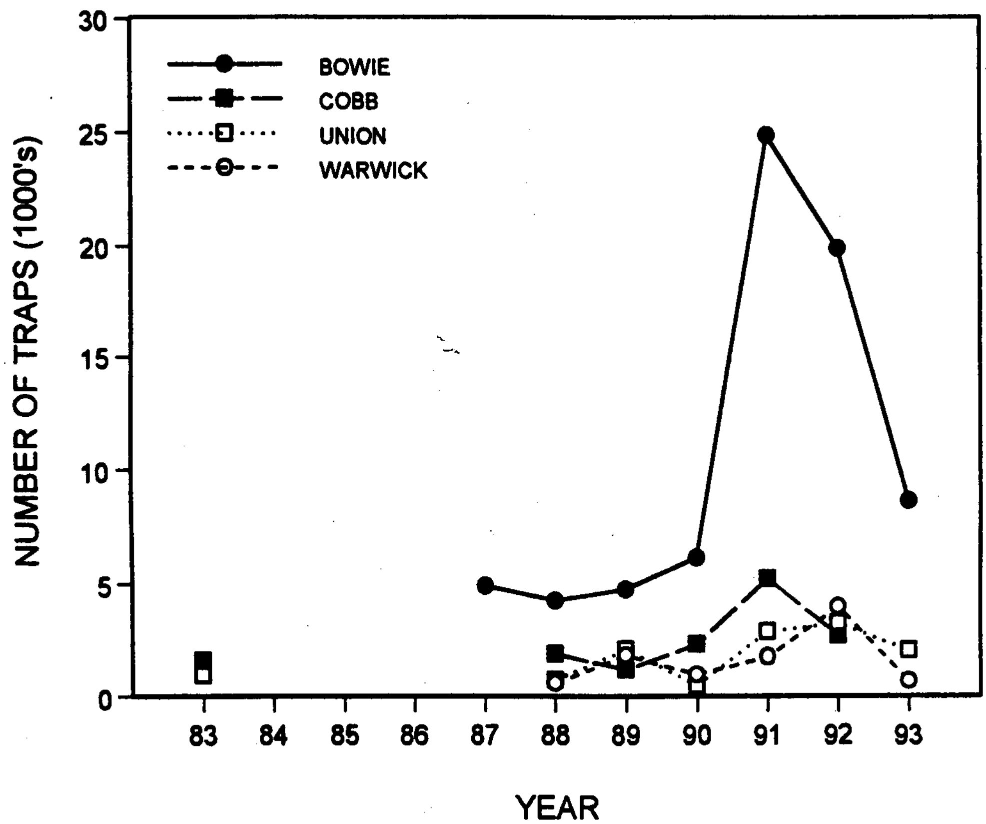

Figure 7. Total annual number of sablefish traps deployed on Bowie, Cobb, Union, and Warwick Seamounts, 1983-1993.

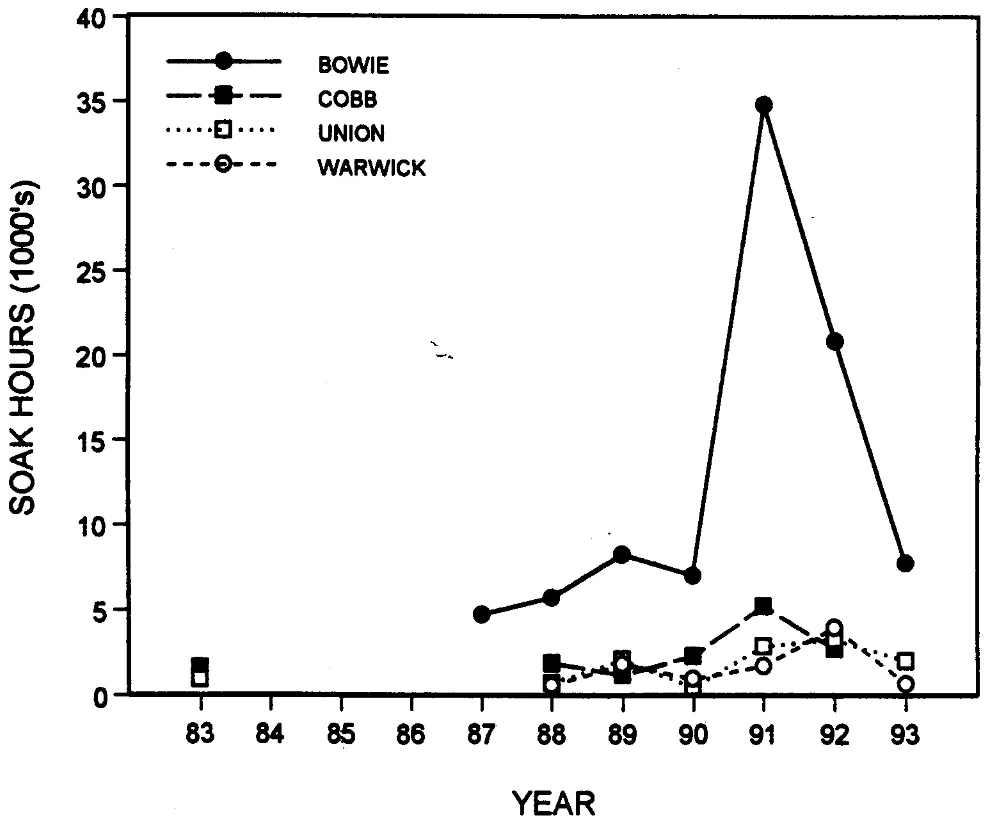

Figure 8. Total annual number of soak hours in the sablefish trap-fishery on Bowie, Cobb, Union, and Warwick Seamounts, 1983-1993.

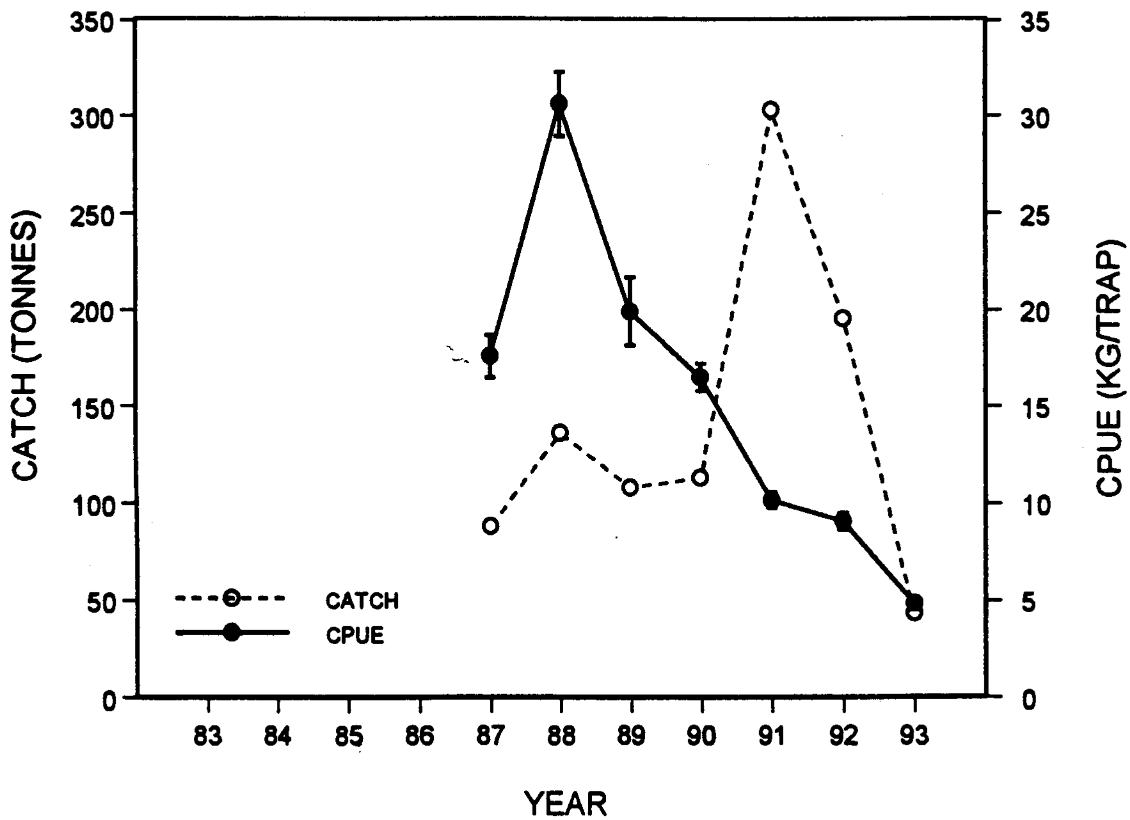

Figure 9. Annual mean catch and annual mean CPUE (±SE) for the sablefish trap-fishery on Bowie Seamount.

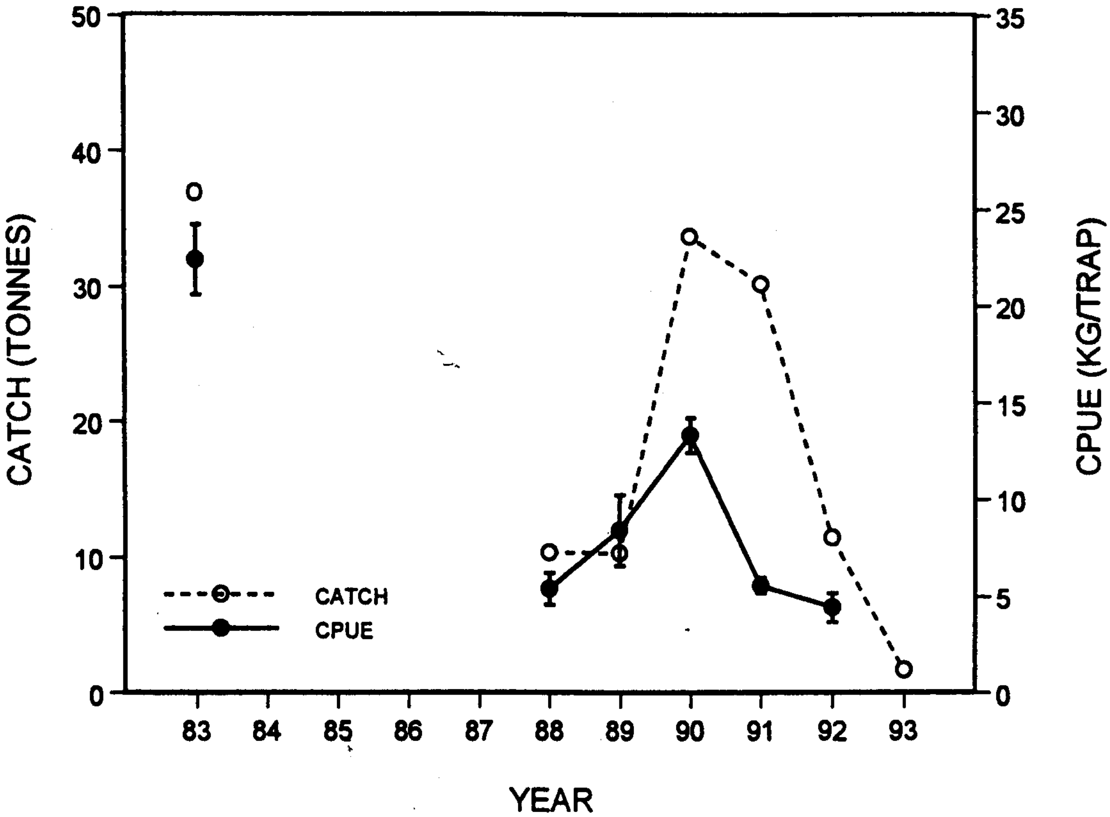

Figure 10. Annual mean catch and annual mean CPUE (±SE) for the sablefish trap-fishery on Cobb Seamount.

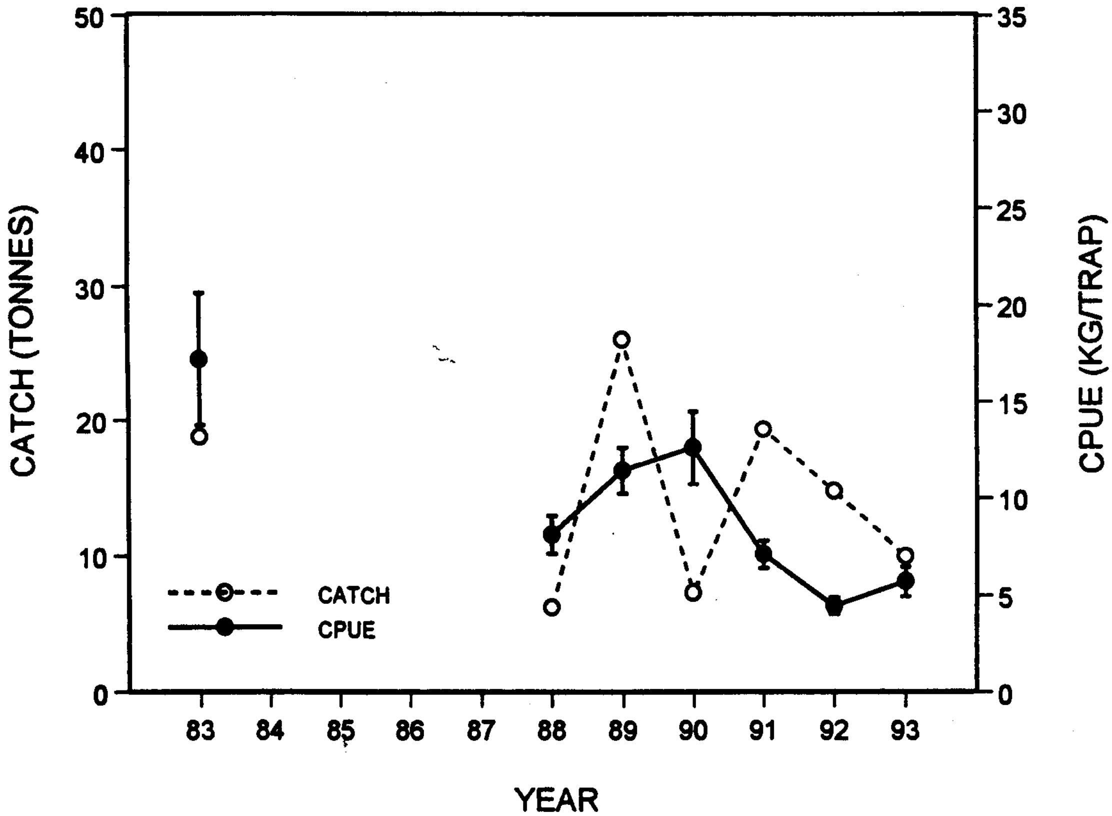

Figure 11. Annual mean catch and annual mean CPUE (±SE) for the sablefish trap-fishery on Union Seamount.

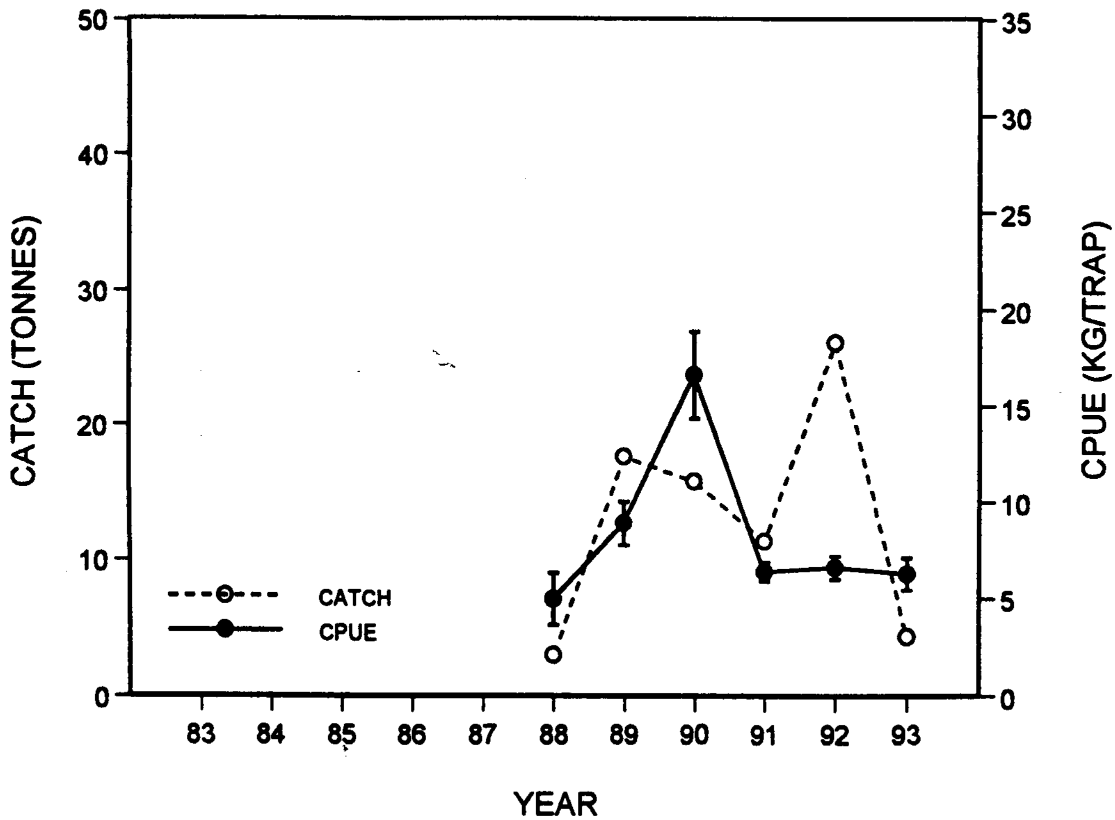

Figure 12. Annual mean catch and annual mean CPUE (±SE) for the sablefish trap-fishery on Warwick Seamount.

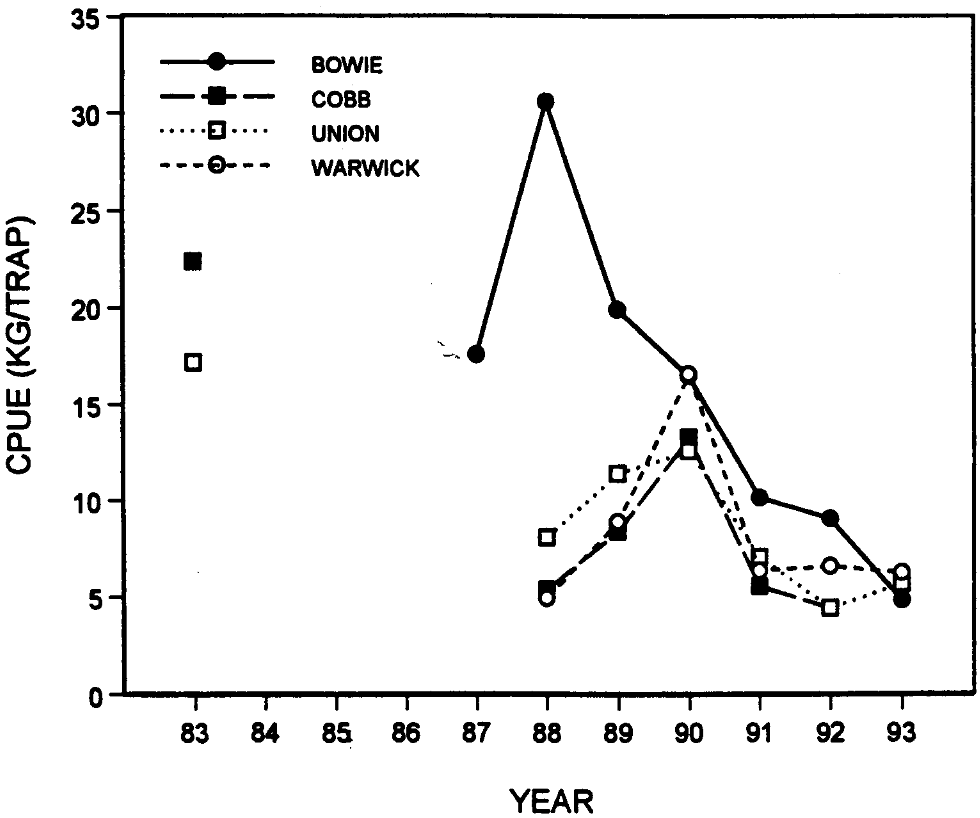

Figure 13. Annual mean CPUE for the sablefish trap-fishery on Bowie, Cobb, Union, and Warwick Seamounts, 1983-1993.

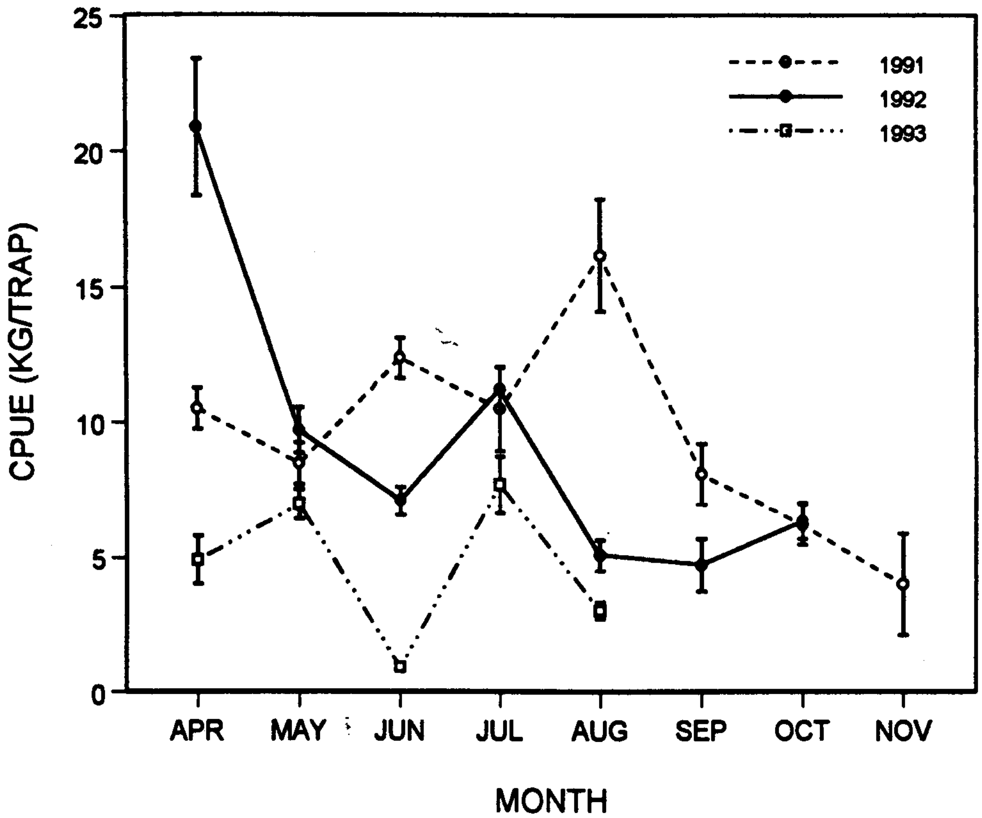

Figure 14. Monthly CPUE (±SE) in 1991, 1992, and 1993 for Bowie Seamount.

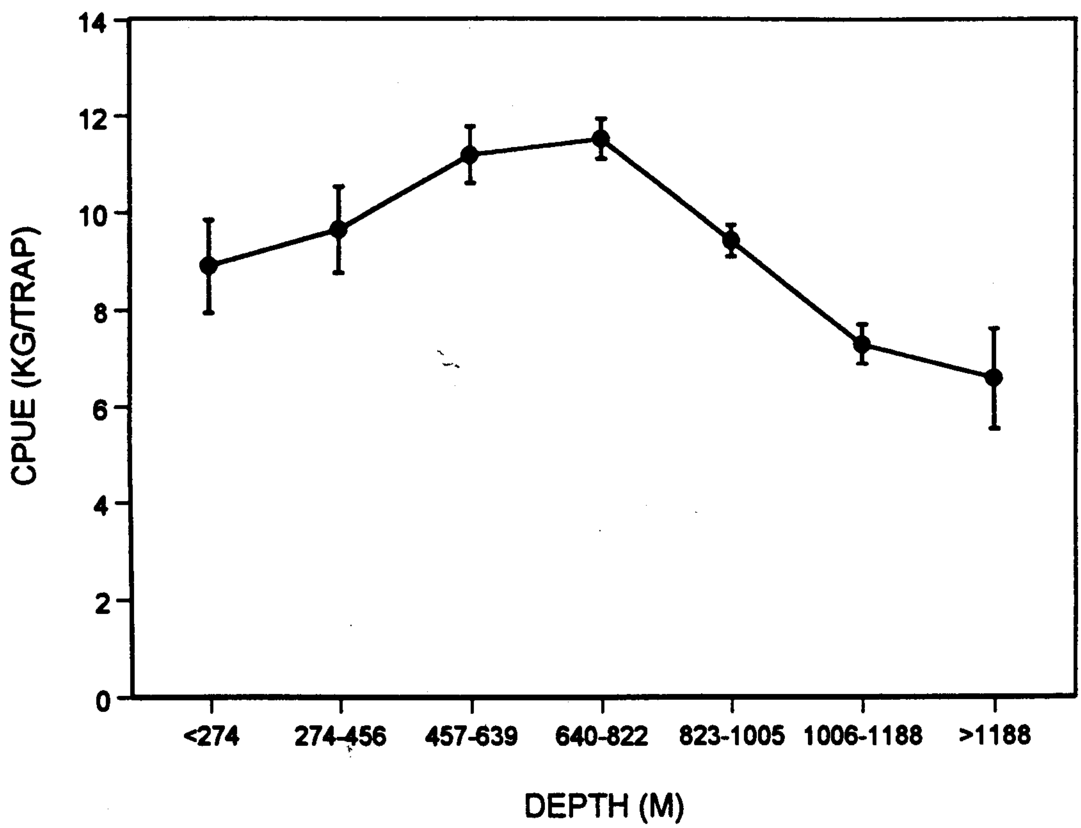

Figure 15. Mean CPUE (± SE) as a function of depth strata for all seamounts pooled.

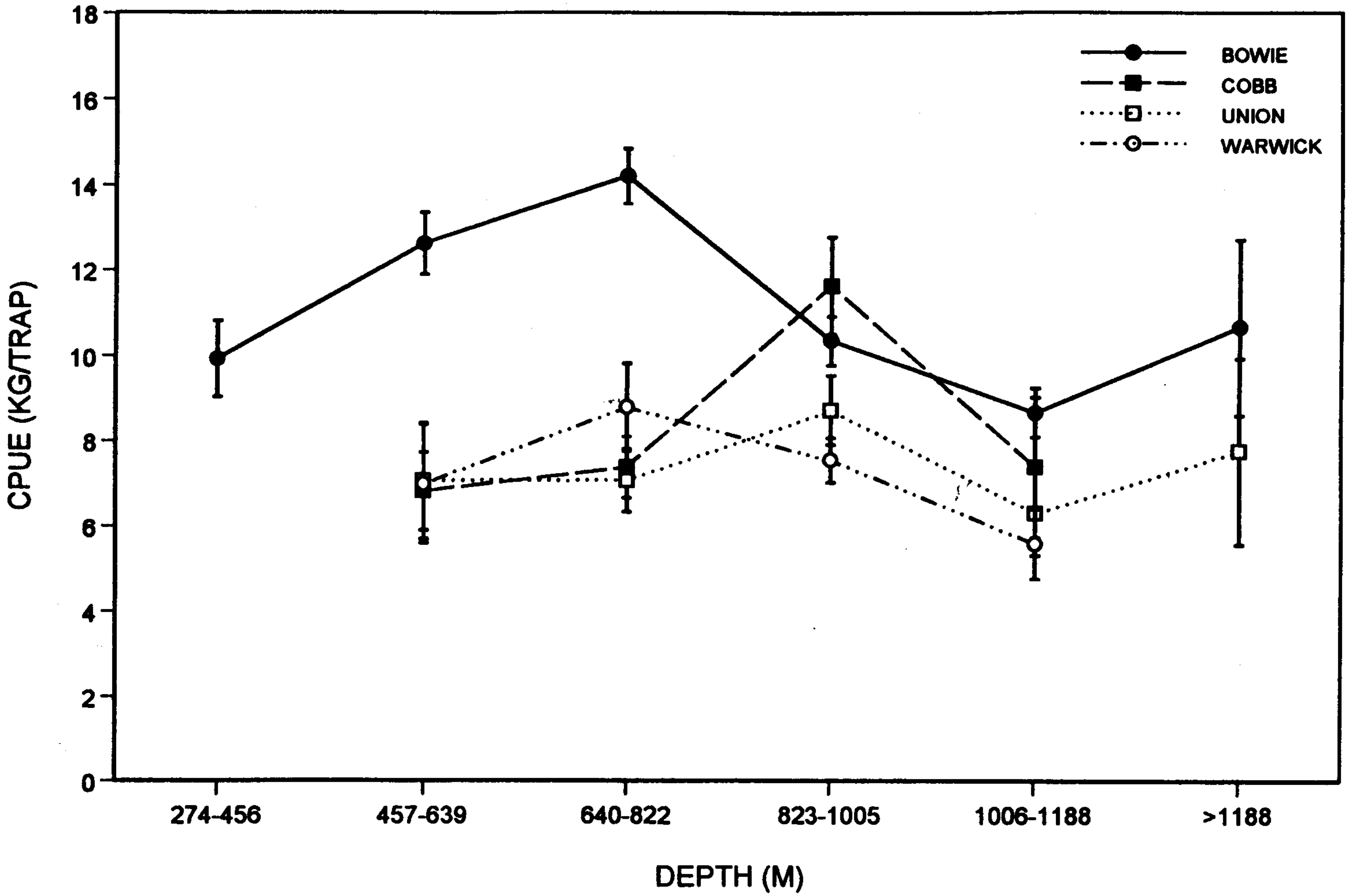

Figure 16. Mean CPUE (±SE) for the sablefish trap-fishery on Bowie, Cobb, Union and Warwick Seamounts as a function of depth strata.

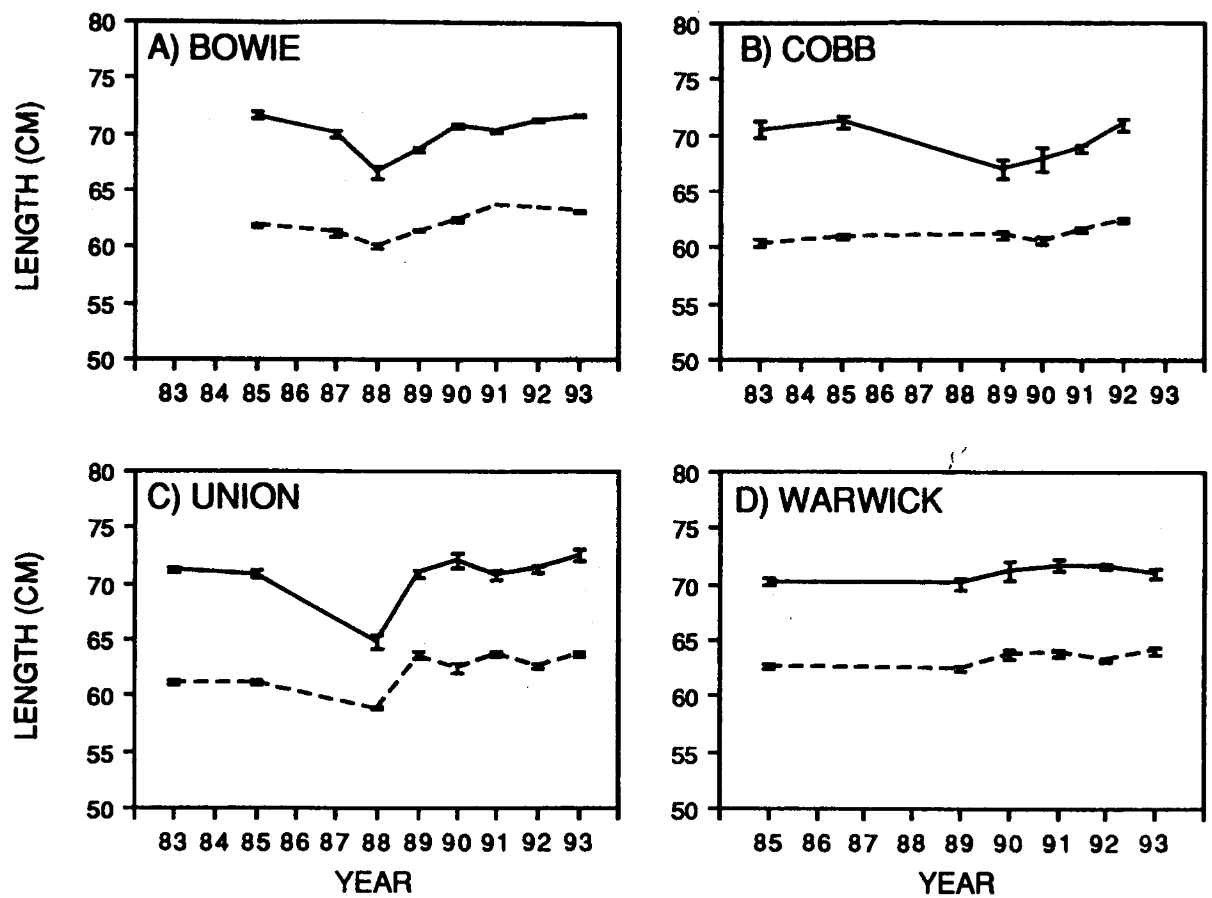

Figure 17. Annual mean fork lengths (± SE) for male (dashed) and female (solid) sablefish sampled from Bowie, Cobb, Union, and Warwick Seamounts, 1983-1993.

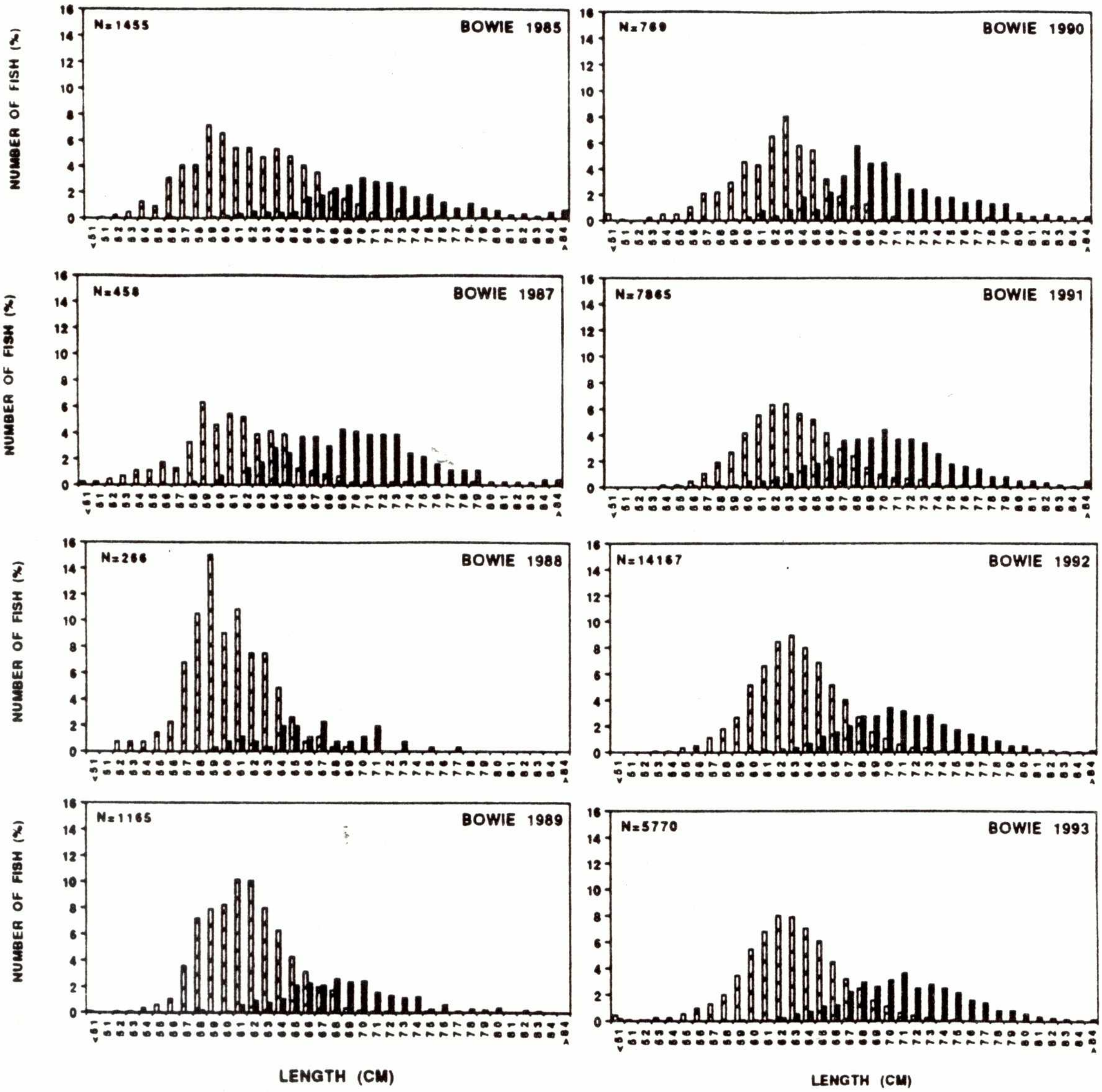

Figure 18. Length frequencies for sablefish sampled from Bowie Seamount, 1985-1993. Males are represented by hatched bars; females by solid bars.

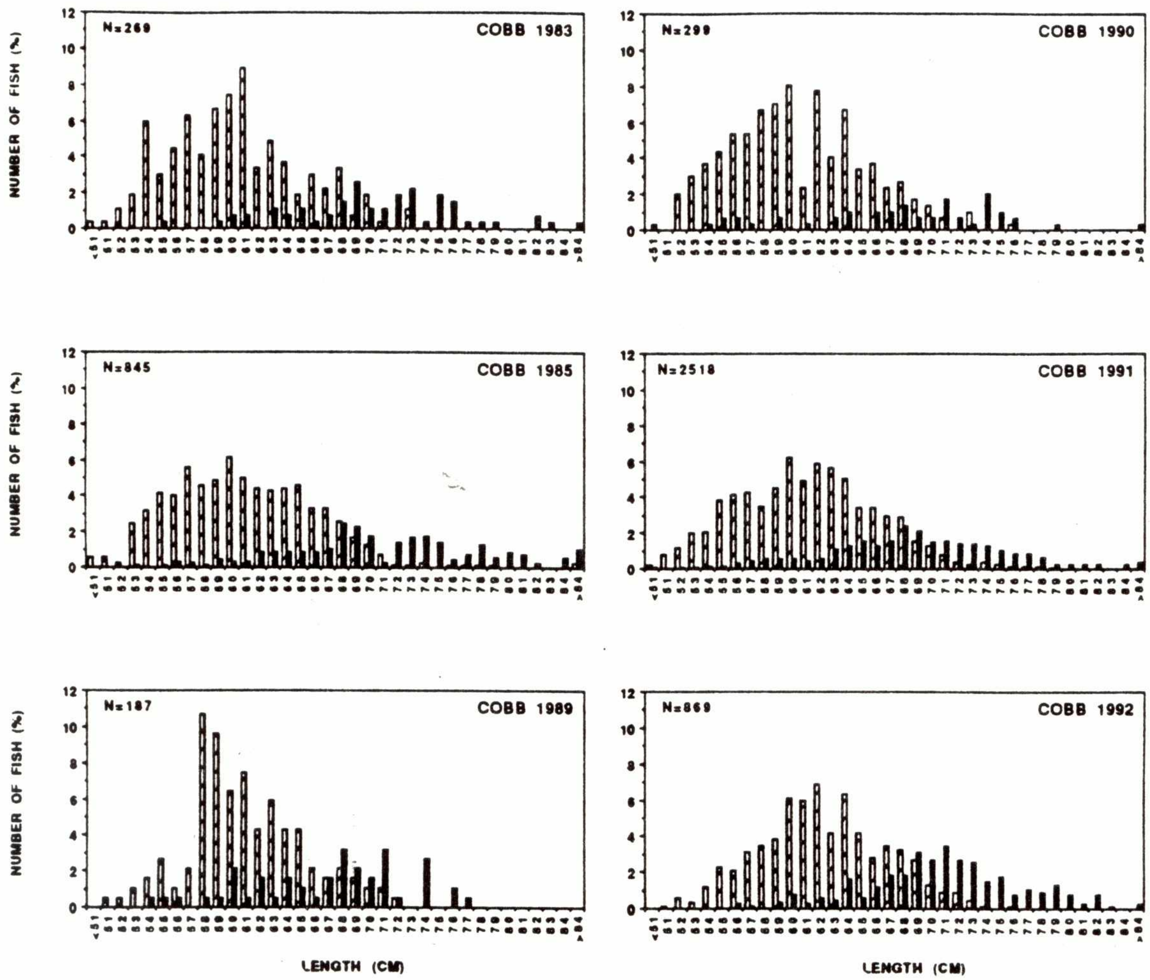

Figure 19. Length frequencies for sablefish sampled from Cobb Seamount, 1983-1992. Males are represented by hatched bars, females by solid bars.

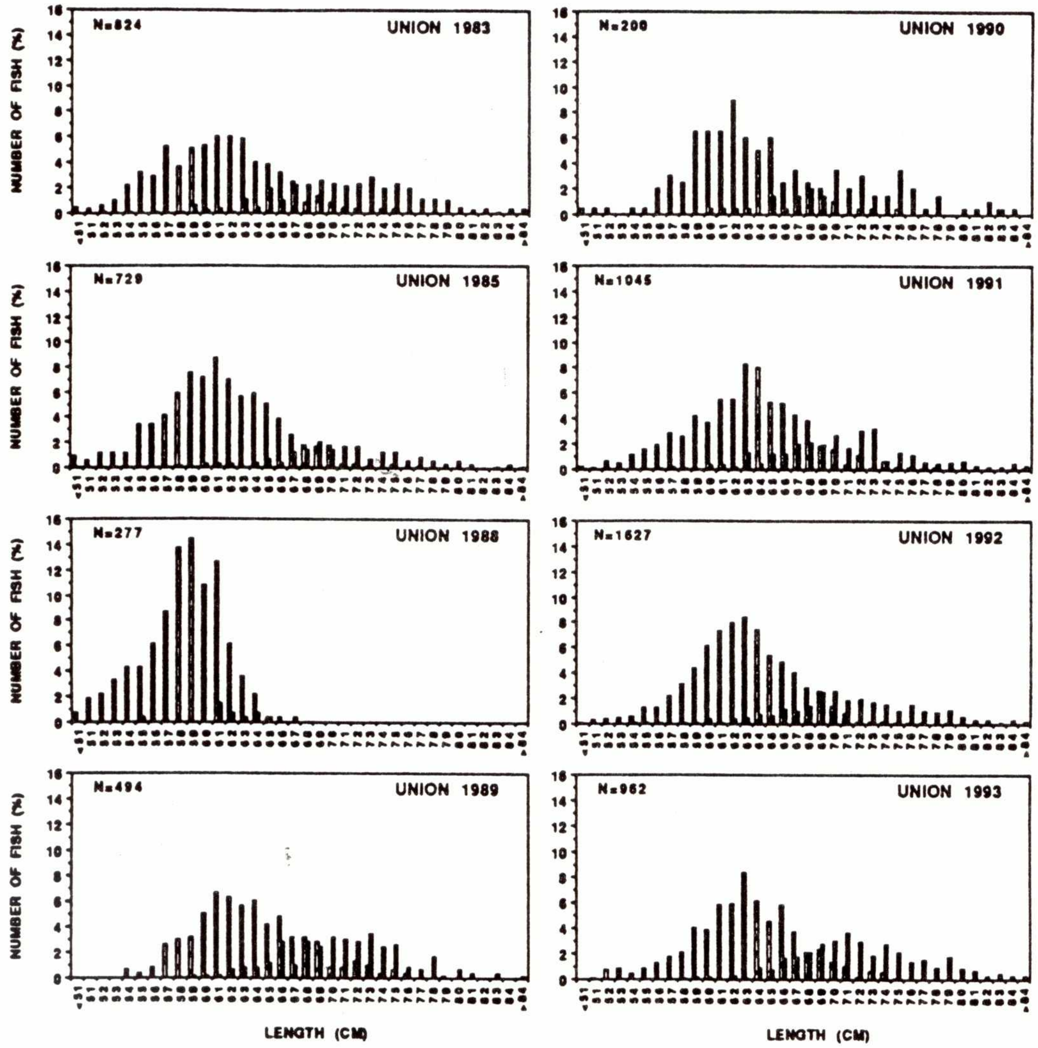

Figure 20. Length frequencies for sablefish sampled from Union Seamount, 1983-1993. Males are represented by hatched bars; females by solid bars.

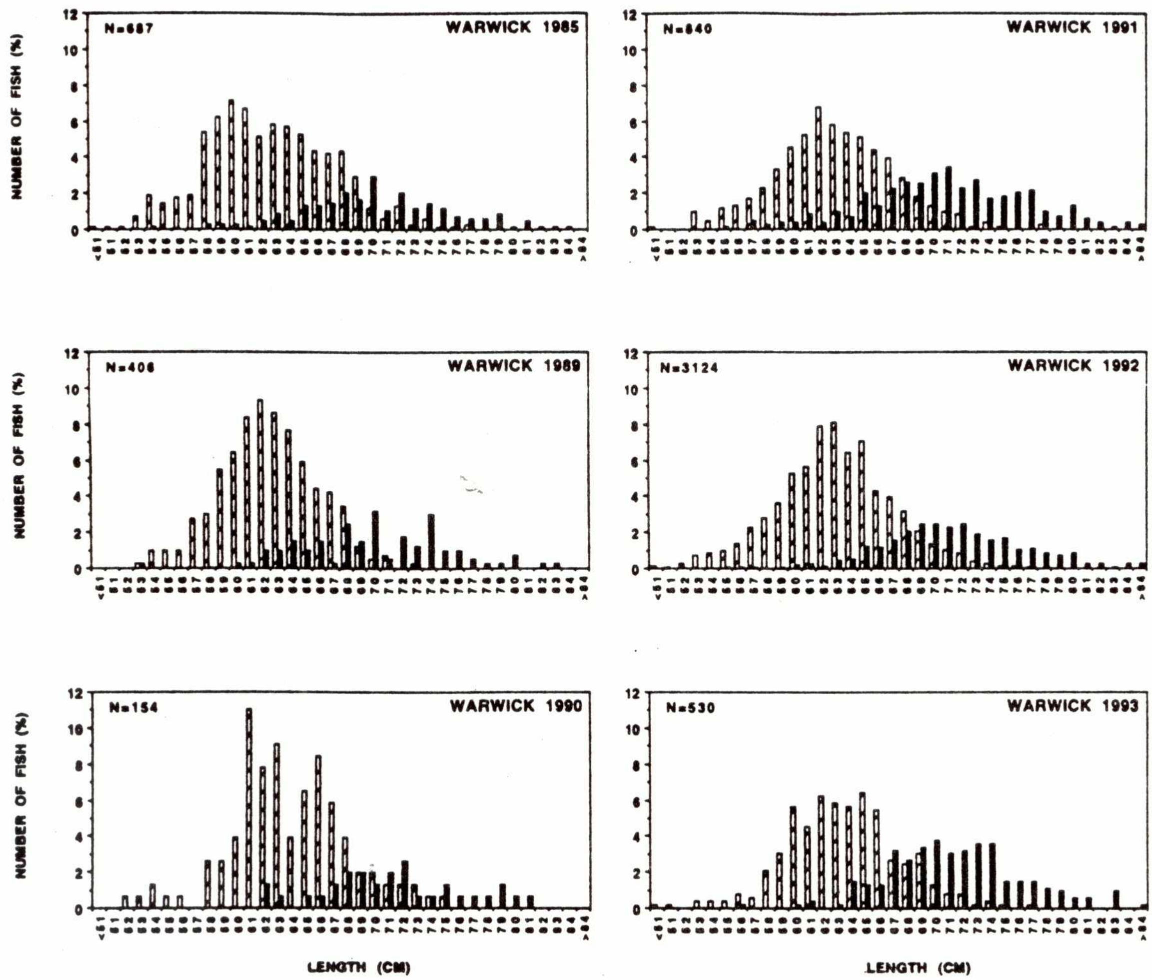

Figure 21. Length frequencies for sablefish sampled from Warwick Seamount, 1985-1993. Males are represented by hatched bars; females by solid bars.

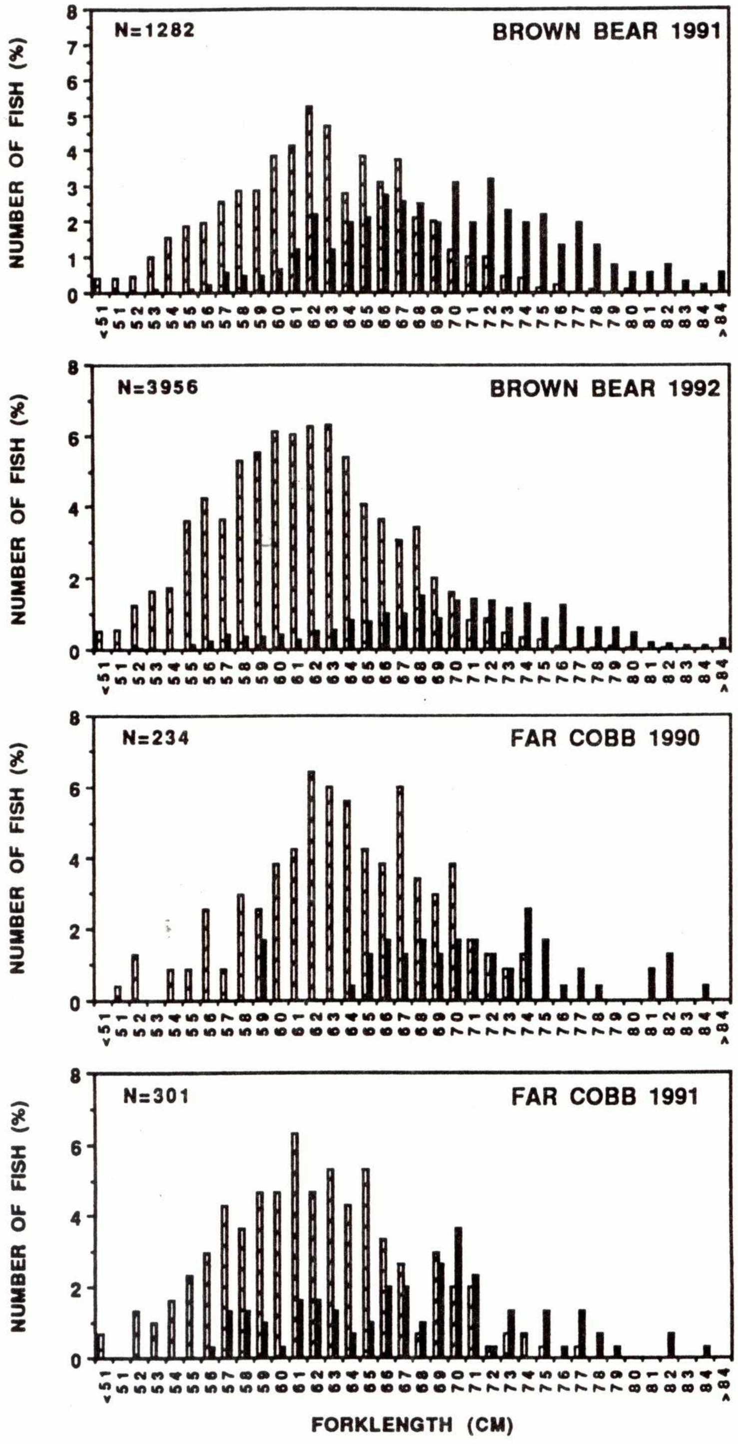

Figure 22. Length frequencies for sablefish sampled from Brown Bear and Far Cobb Seamounts. Males are represented by hatched bars; females by solid bars.

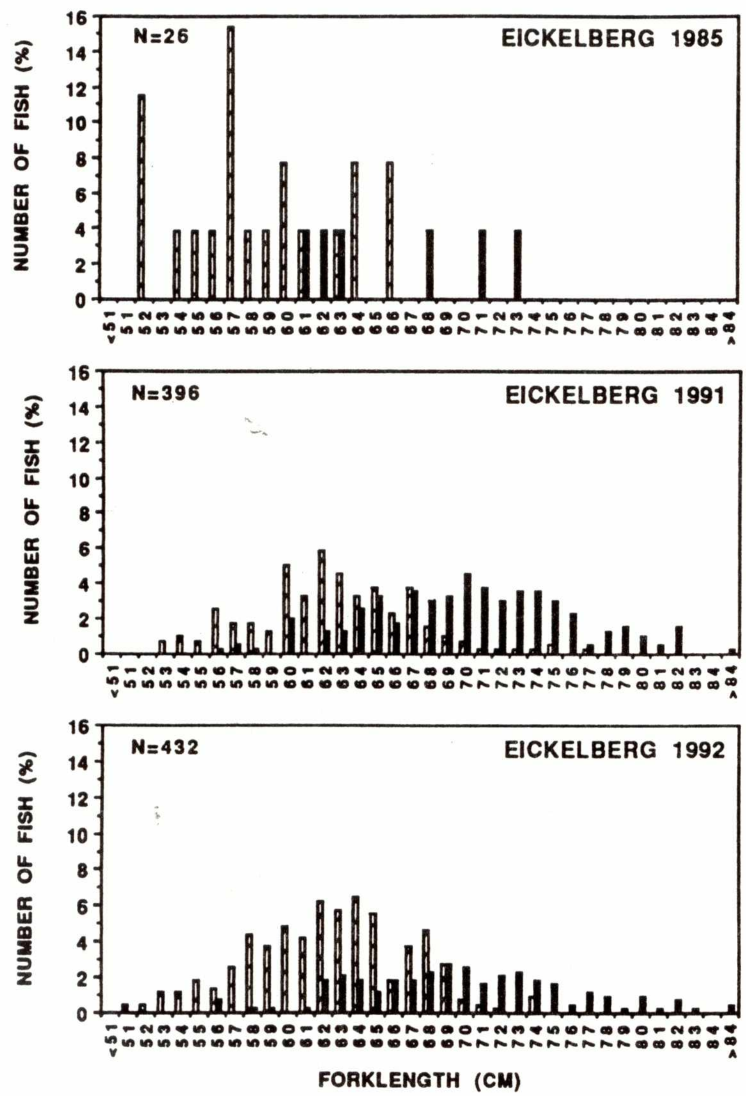

Figure 22 (Cont'd). Length frequencies for sablefish sampled from Eickelberg Seamount. Males are represented by hatched bars; females by solid bars.

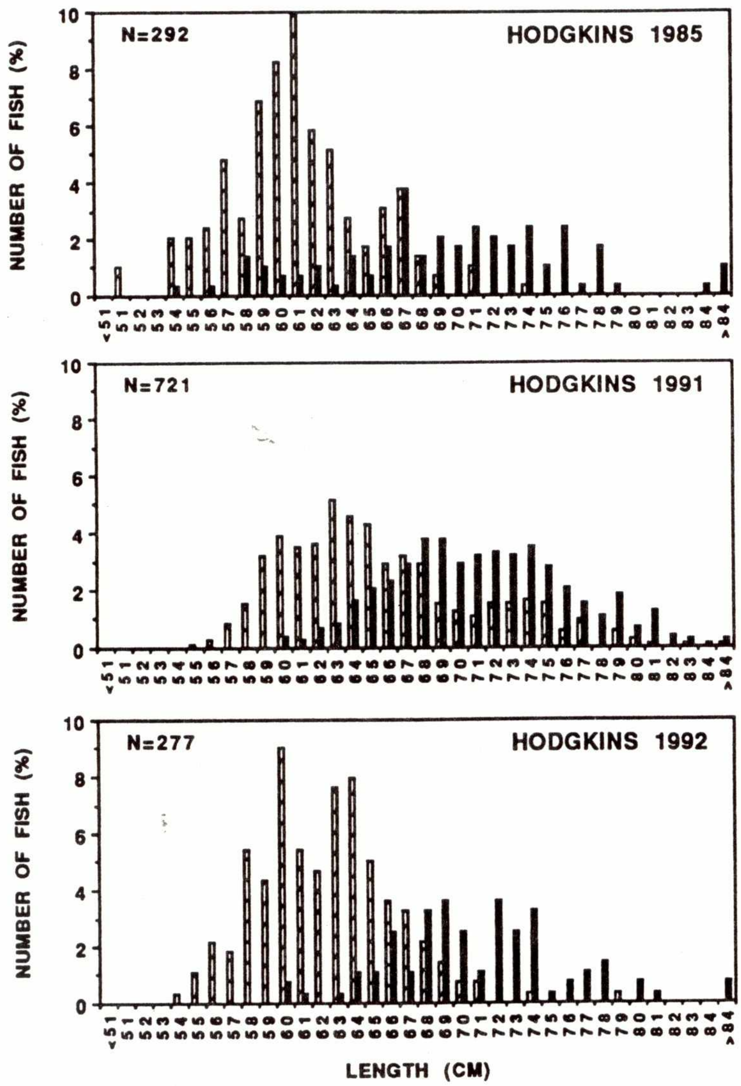

Figure 22 (Cont'd). Length frequencies for sablefish sampled from Hodgkins Seamount. Males are represented by hatched bars; females by solid bars.

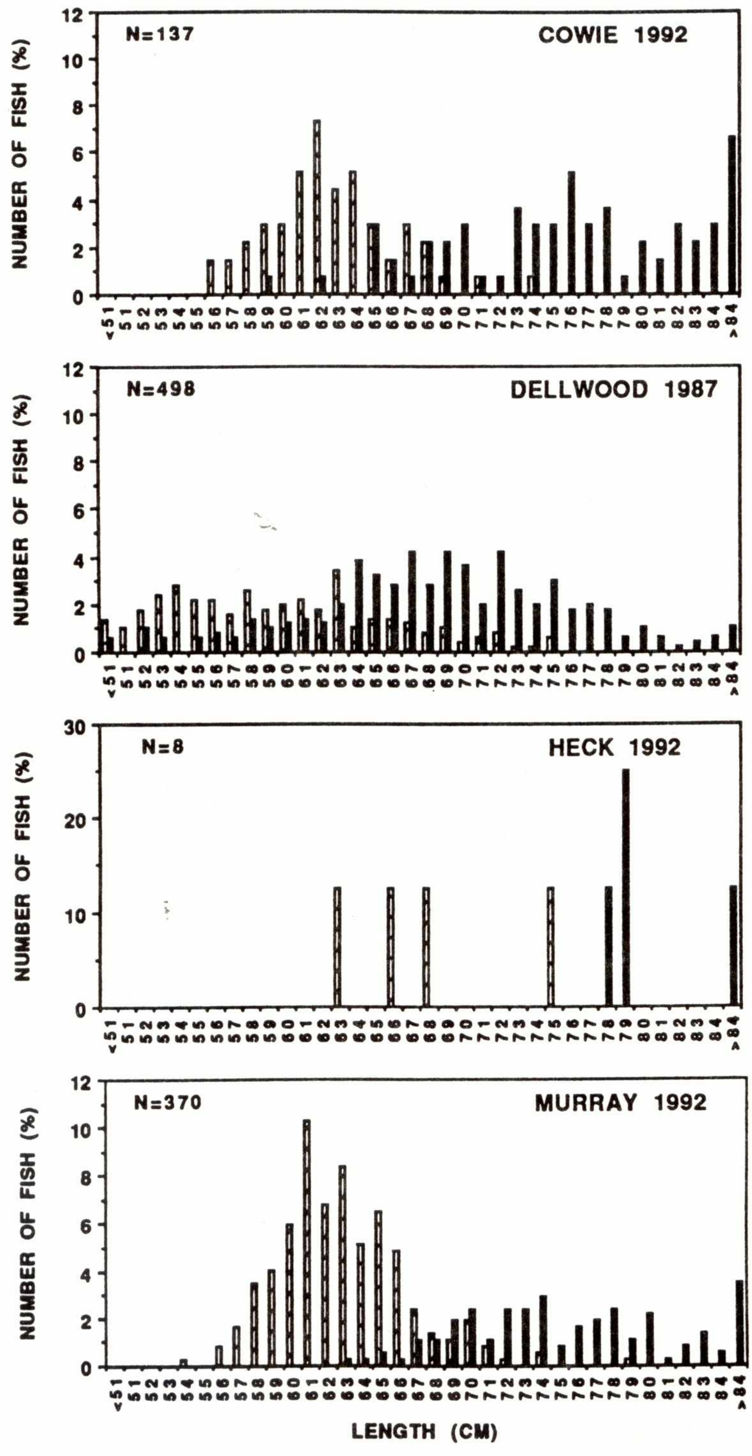

Figure 23. Length frequencies for sablefish sampled from minor seamounts. Males are represented by hatched bars; females by solid bars.

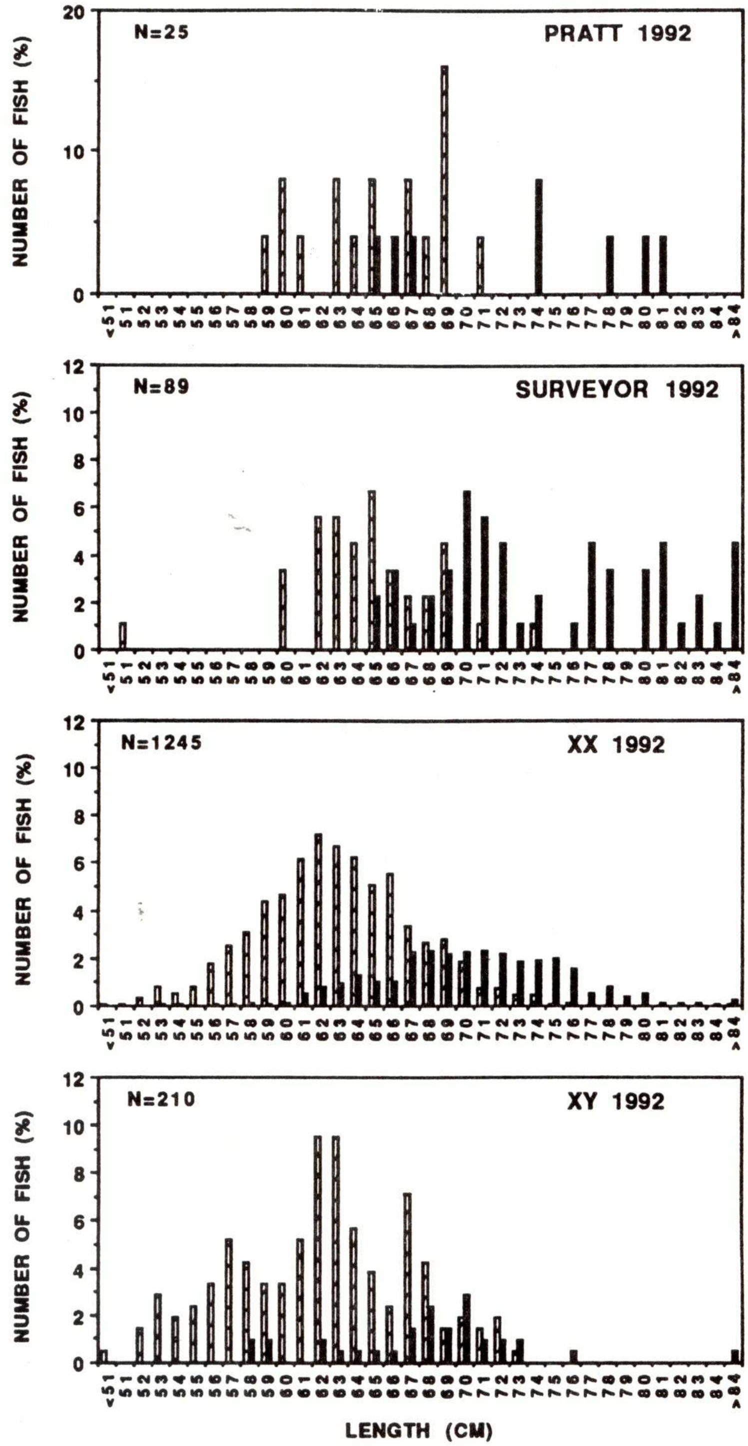

Figure 23 (Cont'd). Length frequencies for sablefish sampled from minor seamounts. Males are represented by hatched bars; females by solid bars.

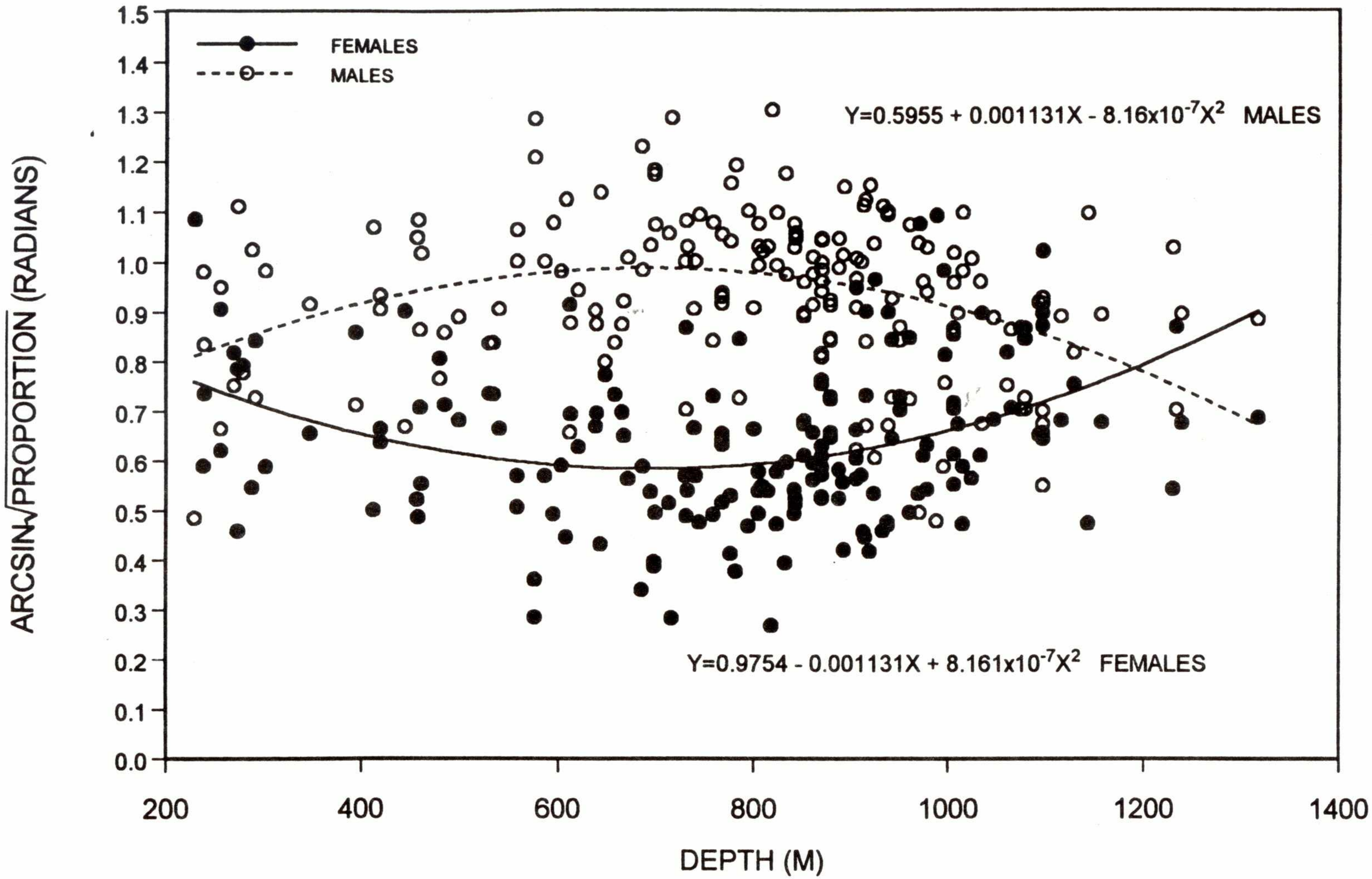

Figure 24. Proportion of male and female sablefish in individual fishing sets from Bowie Seamount in 1991-1993 as a function of depth.

Appendix Table 1. Summary of seamount fishing trips for sablefish using baited longlines (hooks), 1989-1993.

YEAR	DATE	VESSEL	TRIP REPORT NO.[a]	FILE No.[b]	SEAMOUNT
1992	Apr 25-May 18	Nordic Spirit	S-NSP-1-6	92007	Bowie

[a] Trip report numbers were assigned by Archipelago Marine Research, 1991-1993.
[b] File numbers prior to 1991 were assigned by Department of Fisheries & Oceans; file numbers from 1991-1993 were assigned by Archipelago Marine Research.

Appendix Table 2. Summary of seamount fishing trips for sablefish using trawls, 1989-1993.

YEAR	DATE	VESSEL	TRIP REPORT NO.[a]	FILE No.[b]	SEAMOUNT
1988	Jun 15	Arctic Harvester	-	-	Warwick
1989	Oct 11	Eldorado	-	-	Warwick

[a] Trip report numbers were assigned by Archipelago Marine Research, 1991-1993.
[b] File numbers prior to 1991 were assigned by Department of Fisheries & Oceans; file numbers from 1991-1993 were assigned by Archipelago Marine Research.

Appendix Table 3. Summary of directed fishing trips for yelloweye rockfish (*Sebastes ruberrimus*) and rougheye rockfish (*S. aleutianus*) using baited longlines (hooks) on seamounts, 1989-1993.

YEAR	DATE	VESSEL	TRIP REPORT NO.[a]	FILE No.[b]	SEAMOUNT
1992	Aug 3- Aug 10	Storm Dodger	S-SDD-1-17	92049	Bowie
1992	Aug 3-Sep 4	Carribac	S-CRR-1-23	92050	Bowie
1992	Aug 12-Aug 18	Storm Dodger	S-SDD-2-19	92052	Bowie
1992	Aug 18-Sep 3	Storm Dodger	S-SDD-3-20	92056	Bowie
1993	Aug 15-Sep 1	Star	S-STR-1-13	93024	Bowie

[a] Trip report numbers were assigned by Archipelago Marine Research, 1991-1993.
[b] File numbers prior to 1991 were assigned by Department of Fisheries & Oceans; file numbers from 1991-1993 were assigned by Archipelago Marine Research.

Appendix Table 4. Summary of fishing trips targeting on albacore tuna during travel to/from and between fishing trips for sablefish on seamounts, 1989-1993.

YEAR	DATE	VESSEL	TRIP REPORT NO.[a]	FILE NO.[b]	SEAMOUNT
1992	Aug 1-Aug 18	Nopsa	S-NOP-5-18	92047	Cobb Warwick Eickelberg Brown Bear

[a] Trip report numbers were assigned by Archipelago Marine Research, 1991-1993.
[b] File numbers prior to 1991 were assigned by Department of Fisheries & Oceans; file numbers from 1991-1993 were assigned by Archipelago Marine Research.

Appendix Table 5. Summary of type and number of biological samples collected for rougheye rockfish taken by fishing trips targetting on sablefish using traps on seamounts, 1989-1993 (L/S=length and sex; L/S/A=length, sex, and age; L/S/A/STOM=length, sex, age and stomachs).

YEAR	DATE	VESSEL	TRIP REPORT NO.[a]	FILE NO.[b]	SEAMOUNT	TYPE OF SAMPLE: L/S		L/S/A		L/S/A/STOM	
						NO. SAMP.	NO. FISH	NO. SAMP.	NO. FISH	NO. SAMP.	NO. FISH
1989	Jun 1-Jul 19	Viking Sunrise		89001	Bowie	0	0	0	0	1	50[c,d]
1989	Aug 8-Sep 7	Transpacific No.1		89002	Union	0	0	0	0	1	50[e]
1989	Aug 26-Sep 18	Pacific Titan		89003	Warwick	0	0	0	0	1	50[c]
1990	Jun 3-Jul 4	Jeanna Marie		90001	Union	0	0	1	87	0	0
1991	Apr 8-May 10	La Porsche	S-LAP-1-3	91003	Union	0	0	1	50	0	0
1991	May 3-Jun 4	Viking Sunrise	S-SUN-1-5	91004	Bowie	0	0	1	59	0	0
1991	Jun 6-Jul 5	Lana Janine	S-LNJ-1-6	91005	Bowie	0	0	1	46	0	0
1991	Jul 7-Aug 10	Viking Sunrise	S-SUN-2-22	91021	Bowie	0	0	1	48	0	0
1991	Aug 28-Oct 10	Viking Sunrise	S-SUN-4-50	91046	Bowie	0	0	1	50	0	0
1991	Sep 3-Sep 24	Nopsa	S-NOP-2-47	91047	Union	0	0	1	50	0	0
					Cobb	0	0	1	50	0	0

Appendix Table 5 (Cont'd). Summary of type and number of biological samples collected for rougheye rockfish taken by fishing trips targetting on sablefish using traps on seamounts, 1989-1993 (L/S=length and sex; L/S/A=length, sex, and age; L/S/A/STOM=length, sex, age and stomachs).

YEAR	DATE	VESSEL	TRIP REPORT NO.[a]	FILE NO.[b]	SEAMOUNT	TYPE OF SAMPLE: L/S		L/S/A		L/S/A/STOM	
						NO. SAMP.	NO. FISH	NO. SAMP.	NO. FISH	NO. SAMP.	NO. FISH
1992	Apr 8-May 4	La Porsche	S-LAP-1-1	92003	Bowie	0	0	1	50	0	0
1992	Apr 16-May 6	Viking Star	S-VST-1-2	92004	Union	0	0	1	50	0	0
1992	Apr 24-May 6	Transpacific #1	S-TCP-1-3	92008	Union	0	0	2	100	0	0
1992	May 23-Jun 7	Nopsa	S-NOP-2-9	92016	Warwick	0	0	1	50	0	0
1992	May 28-Jul 2	Star Wars	S-SWR-1-12	92017	Bowie	0	0	2	100	0	0
1992	May 30-Jun 30	Westerly Wind	S-WWN-1-10	92019	Union	0	0	1	32	0	0
1992	Jul 2-Aug 2	Viking Sunrise	S-SUN-1-16	92036	Bowie	0	0	2	90	0	0
1992	Jul 30-Sep 4	Pacific Prowler	S-PPR-1-21	92048	Bowie	0	0	1	50	0	0
1992	Aug 29-Sep 19	Viking Sunrise	S-SUN-2-24	92060	Bowie	0	0	2	105	0	0
1992	Sep 30-Oct 10	Nopsa	S-NOP-6-25	92065	Bowie	0	0	1	50	0	0
1993	Mar 31-Apr 14	Star Wars II	S-SWR-1-04	93004	Bowie	0	0	1	56	0	0
1993	Apr 29-May 29	Westerly Wind	S-WWN-1-09	93007	Bowie	0	0	2	100	0	0

Appendix Table 5 (Cont'd). Summary of type and number of biological samples collected for rougheye rockfish taken by fishing trips targetting on sablefish using traps on seamounts, 1989-1993 (L/S=length and sex; L/S/A=length, sex, and age; L/S/A/STOM=length, sex, age and stomachs).

YEAR	DATE	VESSEL	TRIP REPORT NO.[a]	FILE NO.[b]	SEAMOUNT	TYPE OF SAMPLE: L/S		L/S/A		L/S/A/STOM	
						NO. SAMP.	NO. FISH	NO. SAMP.	NO. FISH	NO. SAMP.	NO. FISH
1993	Jun 3-Jun 20	Star Wars II	S-SWR-2-10	93010	Bowie	0	0	1	57	0	0
					Union	0	0	1	59	0	0
1993	Jul 10-Aug 13	Westerly Wind	S-WWN-2-11	93011	Union	0	0	1	55	0	0
					Warwick	0	0	1	59	0	0
1993	Aug 9-Aug 26	Viking Star	S-VST-1-12	93025	Bowie	0	0	2	100	0	0

[a] Trip report numbers were assigned by Archipelago Marine Research, 1991-1993.
[b] File numbers prior to 1991 were assigned by Department of Fisheries & Oceans; file numbers from 1991-1993 were assigned by Archipelago Marine Research.
[c] Frozen in the round, head on, for Department of Fisheries and Oceans port observers.
[d] Labelled as "Redcod".
[e] Random sample for species identification labelled as "Rockfish".

Appendix Table 6. Summary of type and number of biological samples collected for rougheye rockfish taken during fishing trips targetting on sablefish using baited longlines (hooks) on seamounts, 1989-1993 (L/S=length and sex; L/S/A=length, sex, and age; L/S/A/STOM=length, sex, age and stomachs).

YEAR	DATE	VESSEL	TRIP REPORT NO.[a]	FILE NO.[b]	SEAMOUNT	TYPE OF SAMPLE: L/S		L/S/A		L/S/A/STOM	
						NO. SAMP.	NO. FISH	NO. SAMP.	NO. FISH	NO. SAMP.	NO. FISH
1992	Apr 25-May 18	Nordic Spirit	S-NSP-1-6	92007	Bowie	3	570	1	49	0	0

[a] Trip report numbers were assigned by Archipelago Marine Research, 1991-1993.
[b] File numbers prior to 1991 were assigned by Department of Fisheries & Oceans; file numbers from 1991-1993 were assigned by Archipelago Marine Research.

Appendix Table 7. Summary of type and number of biological samples collected for shortraker rockfish taken by fishing trips targetting on sablefish using traps on seamounts, 1989-1993 (L/S=length and sex; L/S/A=length, sex, and age; L/S/A/STOM=length, sex, age and stomachs).

YEAR	DATE	VESSEL	TRIP REPORT NO.[a]	FILE NO.[b]	SEAMOUNT	TYPE OF SAMPLE: L/S		L/S/A		L/S/A/STOM	
						NO. SAMP.	NO. FISH	NO. SAMP.	NO. FISH	NO. SAMP.	NO. FISH
1990	May 26-Jul 7	Viking Sunrise		90002	Bowie	2	118	0	0	0	0

[a] Trip report numbers were assigned by Archipelago Marine Research, 1991-1993.
[b] File numbers prior to 1991 were assigned by Department of Fisheries & Oceans; file numbers from 1991-1993 were assigned by Archipelago Marine Research.

Appendix Table 8. Summary of differences in CPUE among years and among depths for Bowie, Cobb, Union, and Warwick Seamounts, by order of decreasing means. Years and depths that were significantly different ($P \leq 0.05$) from one another are not underlined; those that were not significantly different are underlined.

Comparison	Seamount	ANOVA	SNK Comparison						
CPUE among years	Bowie	P < 0.001	88	89	87	90	91	92	93
	Cobb	P < 0.001	83	90	89	91	88	92	
	Union	P < 0.001	83	90	89	88	91	93	92
	Warwick	P < 0.001	90	89	92	91	93	88	
CPUE among depths(m)	Bowie	P < 0.001	640-822	457-639	>1188	823-1005	274-456	1006-1188	
	Cobb	P < 0.001	823-1005	640-822	1006-1188	457-639			
	Union	P < 0.419	823-1005	640-822	457-639	1006-1188			
	Warwick	P < 0.224	640-822	823-1005	457-639	1006-1188			

Appendix Table 9. Summary of differences in length for males and females among years for Bowie, Cobb, Union, and Warwick Seamounts, by order of decreasing means. Years that were significantly different ($P \leq 0.05$) from one another are not underlined; those that were not significantly different are underlined.

Sex of fish	Seamount	ANOVA	SNK Comparison							
Males	Bowie	P < 0.001	91	92	93	90	85	89	87	88
	Cobb	P < 0.001	92	91	89	85	90	83		
	Union	P < 0.001	93	91	89	92	90	83	85	88
	Warwick	P < 0.001	93	91	90	92	85	89		
Females	Bowie	P < 0.001	85	93	92	90	91	87	89	88
	Cobb	P < 0.001	85	92	83	91	90	89		
	Union	P < 0.001	93	90	92	83	89	85	91	88
	Warwick	P < 0.065	91	92	90	93	85	89		