# CHANGES IN RELATIVE ABUNDANCE AND SIZE COMPOSITION OF SABLEFISH IN COASTAL WATERS OF WASHINGTON AND OREGON 1979-85 

by

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## ABSTRACT

Survey results indicated sablefish (Anoplopoma fimbria) abundance off Oregon and Washington decreased between 1979 and 1981, increased between 1981 and 1983, and then dropped back to a point midway between 1979 and 1981 population levels in 1985. The 1985 catches at four index sites sampled since 1979 were composed of a much higher percentage (i.e., 59\%) of submarketable-size $(<52 \mathrm{~cm})$ sablefish and a much lower percentage of medium and large marketable sablefish (4 and 2\%, respectively) than in any of the previous surveys: Size composition at seven of the eight sites sampled in 1985 was similar. Fish captured at the northernmost site (Nitinat Canyon) adjacent to the Canadian Fishery Zone were on the average much larger than at other sites, although few in number. The mean size of sablefish has continued to decline off the coast of Oregonand Washington since 1979; catch rates indicate that total sablefish abundance has declined approximately $33 \%$ since that time.

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## INTRODUCTION


#### Abstract

The economic importance of the sablefish (Anoplopoma fimbria) fishery (Korson 1986) and the need for information to supplement status of stock analyses were responsible for the initiation of a program at the Northwest and Alaska Fisheries Center (NWAFC) to monitor changes in distribution,


 relative abundance, size composition, biological characteristics, and movements of sablefish in the northeastern Pacific Ocean. Surveys to measure changes in sablefish relative abundance at specific index sites began in southeastern Alaska waters in 1978, were extended to Oregon and Washington waters in 1979, and to waters off California in 1980. The results of $1979-84$ surveys in the Washington-California region have been reported by Parks and Hughes (1981), Parks (1982, 1984), and Parks and Shaw (1983, 1985). This report presents results of the 1985 survey off Washington and Oregon with comparisons to previous surveys. The primary objective was to obtain catch per unit effort (CPUE) indices of sablefish abundance at preselected index sites as a means of monitoring population trends. Secondary objectives included the collection of biological data on the state of maturity, length, and age composition, the tagging of sablefish in a continuing effort to understand population movements and to identify discrete stocks, and the comparison of catch rates from conical and rectangular traps as part of our process of completing the transition from rectangular to conical traps as the sampling gear. In an effort to find more efficient and less labor-intensive sampling gear, conical (Korean) style traps were introduced in 1983 and their catches have since been compared with catches by rectangular traps which have been used from the beginning of the study. The 1983 comparisons of relative fishing efficiencies of the two trap types were inconclusive (Parks 1984). The 1984 comparisons were conducted off California and southern Oregon and indicated that the conical traps were 1.26 times more```
efficient than rectangular traps. The observed difference was statistically
significant (Parks and Shaw 1985). The 1985 comparisons were conducted to
determine if the same relationship held in the area off Washington and Oregon.
SURVEY METHODS AND GEAR
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The basic survey design and sampling gear are described in detail by Parks and Hughes (1981). In 1983, the experimental design was modified in an effort to improve the survey's sensitivity to population changes. Analysis of past Washington-Oregon survey data indicated that substantially smaller changes in abundance could be detected if the number of index sites was increased (Kimura and Balsiger 1985). That analysis also indicated that little loss of precision would occur if the number of replicate sets at an index site was reduced from four to one. By reducing the number of replicate sets, time was provided for sampling at additional locations and the number of index sites off Washington and Oregon was doubled from four to eight in 1985 (Fig. 1). A summary of the sites fished, including dates, depths, sets, and number of traps fished during sablefish indexing surveys off Washington and Oregon in 1979-85, is shown in Table 1.

Rectangular traps are 34 in $x 34$ in $x 8$ ft, and have a single tunnel located on one end. The conical traps have a bottom ring of 54 in (outside diameter), a top ring of 33.5 in (outside diameter), a height of 28 in, and a tunnel entrance on the side. The traps were attached to 5/8-in groundlines 550 fathoms in length at intervals of 50 fathoms. Trap bridles were attached to the groundline by means of gangions using brummel hooks or "C" hooks. The two trap types were alternately positioned on each string (five rectangular and five conical per string) to compare their catching efficiencies.


Figure 1.--Location of sablefish abundance indexing sites off Washington and Oregon, 1983-85.

Table 1 .--Summary of sites fished, including dates, depths, sets, and number of traps fished during sablefish indexing surveys off Washington and Oregon, 1979-85.

|  | Dates |  |  |
| :--- | :--- | :---: | :---: |
| fite | Depths |  |  |$\quad$| Sets |
| :---: |
| fished |$\quad$| No. of traps fished |
| :---: |

1979

Cape Arago, OR
Cape Lookout, OR
Willapa Bay, WA
Cape Johnson, WA

| $8-13$ | Aug | $150-450$ | 5 | 250 |
| ---: | :--- | :--- | :--- | :--- |
| $17-23$ | Aug | $150-450$ | 5 | 250 |
| $6-13$ | Sep | $150-450$ | 5 | 250 |
| $16-21$ | Sep | $150-450$ | 5 | 250 |

1980

| Cape Arago, OR | $6-10$ Aug | $150-450$ | 5 | 250 | 0 |
| :--- | :---: | :--- | :--- | :--- | :--- | :--- |
| Cape Lookout, OR | $12-19$ Aug | $150-450$ | 5 | 250 | 0 |
| Willapa Bay, WA | $10-16$ Sep | $150-450$ | 5 | 250 | 0 |
| Cape Johnson, WA | $21-26 \mathrm{Sep}$ | $150-450$ | 5 | 250 | 0 |

1981

| Cape Arago, OR | $5-11$ Aug | $150-450$ | 5 | 250 | 0 |
| :--- | :--- | :--- | :--- | :--- | :--- |
| Cape Lookout, OR | $13-19$ Aug | $150-450$ | 5 | 250 | 0 |
| Willapa Bay, WA | $19-28$ Sep | $150-450$ | 5 | 250 | 0 |
| Cape Johnson, WA | $11-16 \mathrm{Sep}$ | $150-450$ | 5 | 250 | 0 |

## 1983

| Cape Arago, OR | $26-28$ | Oct | $150-450$ | 2 | 50 | 50 |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| Cape Lookout, OR | $23-24$ | Oct | $150-450$ | 2 | 50 | 50 |
| Willapa Bay, WA | $16-18$ | Oct | $150-450$ | 2 | 50 | 50 |
| Cape Johnson, WA | $13-14$ | Oct | $150-450$ | 2 | 50 | 50 |

1985

| Cape Arago, OR | $\mathbf{1 6 - 1 8}$ | Aug | $\mathbf{1 5 0 - 4 5 0}$ | 2 | $\mathbf{5 0}$ | $\mathbf{5 0}$ |
| :--- | ---: | :--- | :--- | :--- | :--- | :--- |
| Yaquina Bay, OR | $\mathbf{2 0 - \mathbf { 2 1 }}$ Aug | $\mathbf{1 5 0 - 4 5 0}$ | 2 | $\mathbf{5 0}$ | $\mathbf{5 0}$ |  |
| Cape Lookout, OR | $\mathbf{2 3 - \mathbf { 2 4 }}$ Aug | $\mathbf{1 5 0 - \mathbf { 4 5 0 }}$ | 2 | $\mathbf{5 0}$ | $\mathbf{5 0}$ |  |
| Tillamook Head, OR | $\mathbf{2 7 - \mathbf { 2 8 }}$ Aug | $\mathbf{1 5 0 - \mathbf { 4 5 0 }}$ | 2 | $\mathbf{5 0}$ | $\mathbf{5 0}$ |  |
| Willapa Bay, WA | $\mathbf{2 -} \mathbf{3}$ Sep | $\mathbf{1 5 0 - 4 5 0 ,}$ | $\mathbf{5 2 5}$ | 2 | $\mathbf{5 0}$ | $\mathbf{7 0}$ |
| Cape Elizabeth, WA | $\mathbf{5 -} \mathbf{7}$ Sep | $\mathbf{1 5 0 - 4 5 0 ,}$ | $\mathbf{5 2 5}$ | 2 | $\mathbf{5 0}$ | $\mathbf{7 0}$ |
| Cape Johnson, WA | $\mathbf{9 - 1 0}$ Sep | $\mathbf{1 5 0 - 4 5 0 ,}$ | $\mathbf{5 2 5}$ | 2 | $\mathbf{5 0}$ | $\mathbf{7 0}$ |
| Nitinat Canyon, WA | $\mathbf{1 3 - 1 4}$ Sep | $\mathbf{1 5 0 - 4 5 0 ,}$ | $\mathbf{5 2 5}$ | 2 | $\mathbf{5 0}$ | $\mathbf{7 0}$ |

A string of 10 traps was fished twice at each of five depths (150, 225, 300, 375, and 450 fathoms) at each indexing site. Fishing time was standardized to 24 hours per set. Loran $C$ and depth sounders were used to position replicate sets as near as possible to the same depths and locations of first sets. As time and conditions allowed, conical traps were fished in 525 fathoms at the four northern sites to determine sablefish CPUE in depths beyond the standard survey depths.

Data collected included:

1) Species composition of the catch in each trap by number and weight;
2) Fork lengths of all sablefish; and
3) Biological data to support life history studies (e.g., otoliths, for age determination, sex ratios, and measure of maturation). Each of the 1,270 sablefish from which otoliths were taken were weighed to the nearest gram using a high resolution triple beam balance.

All sablefish not required for biological samples were tagged and released in support of ongoing coastwide migration and tag loss studies.

## RESULTS AND DISCUSSION

Sampling was conducted from south to north during August-September 1985. The four new sites identified as Yaquina Bay, Tillamook Head, Cape Elizabeth, and Nitinat Canyon were spaced approximately equidistant among the original sites (Fig. 1). The experimental design calls for the data from all index sites to be combined to determine the changes in sablefish abundance and size composition for the entire survey area; thus individual site data are not discussed. We have included individual site information in the Appendix for those interested in subarea results. Appendix Table 1 shows mean numbers of sablefish captured in terms of conical trap units by site, year, and size
categories. Appendix Table 2 presents the percentage abundance of sablefish by site and size categories.

## Comparison of Trap Types

In 1985, there was considerable variation in catch rates between trap types on individual strings (Fig. 2) as was also observed in 1983 and 1984. The conical traps captured from 27 to $90 \%$ of the sablefish in a set. Overall, conical traps captured $40.8 \%$ more sablefish than rectangular traps. Mean lengths of sablefish captured in conical and rectangular traps were nearly identical at 52.07 and 52.16 cm , respectively. Length distributions were also very similar (Fig. 3) even though the mesh size was larger in the rectangular traps (3-1/2 in) than in the conical traps (2-1/4 in). These results are consistent with previous observations (Auke Bay Laboratory 1983, Parks 1984, Clausen and Fujioka 1985, Parks and Shaw 1985) and it appears that the two trap types sample the population size composition in a like fashion. Statistical analyses were applied to survey results to examine the differences in conical and rectangular trap catches. The ratio estimator used was:

79


1985
79
$\sum \quad r_{i}$
$\mathbf{i =} \quad$ where $\mathrm{Ci}=$ catch in numbers of sablefish in conical traps in haul $i$ and ri $=\operatorname{catch}(n)$ of sablefish in rectangular traps in haul i.

Using a normal approximation given in Cochran (1977: equations 6.13 and 6.151, a $95 \%$ confidence interval for this $R$ is $1.277-1.540^{\prime}$. If the null hypothesis
-'The variance of the conical trap catch appears to be approximately proportional to the rectangular trap catch which implies that the ratio estimator was approximately the best linear unbiased estimator of the regression coefficient describing the regression line of conical trap catches on rectangular trap catches which passes through the origin.


[^0]

Figure 3. --Sablefish length compositions and mean-lengths by trap type during 1985 National Marine Fisheries Service survey.
is that $R=1.0$ (i.e., there is no difference between trap catches), then $R$ is significantly different from 1.0 at the 95\% level ( $\mathrm{P}<0.00001$ ), meaning conical traps caught significantly more sablefish than aid rectangular traps. We have assumed that $\mathrm{R}_{1985}$ is a representative measure of relative fishing power and have applied the correction factor of 1.408 to rectangular trap catches from 1979 to 1985 so that all catch rates presented herein are expressed in terms of catch per conical trap. The 1983 trap comparison studies were inconclusive because the use of new unseasoned conical traps seemed to introduce a bias in their capture efficiency (Parks and Shaw 1985) and, therefore, that data was not used in calculating a correction factor. The 1984 trap comparison data for California and southern Oregon was used to calculate a distinct correction factor (1.265) for that region because it represents a distinct survey area and relative trap efficiencies could vary between region.

Clausen and Fujioka (1985) found no significant difference between catch rates of rectangular and conical trap catch rates in southeastern Alaska waters. Clausen and Fujioka (1987) also found that seemingly slight differences in tunnel design can have a marked effect on catch rates. Rather than using trap tunnels as delivered by the manufacturer, we individually modified and adjusted each conical trap tunnel making it more uniform and efficient resulting in higher catch rates by our conical traps.

## Catch Rates and Size Composition

Annual trends in relative population abundance were examined by utilizing data collected only from the four original index sites as they were common to all survey years. Because only two sets per depth were made at each site since 1983, comparisons were made using catches taken by just the first two of five sets made in 1979, 1980, and 1981. The catch rate comparisons indicate that overall sablefish abundance dropped about 50\% between 1979 and 1981, increased
sharply between 1981 and 1983, and then declined again between 1983 and 1985 (Fig. 4). This decline in sablefish average catch rates from 10.6 fish per trap in 1983 to 7.6 in 1985 is statistically significant at the $96.2 \%$ level using Rubin's method (Knechtel 1986: appendix C). The coefficients of variation of these catch rates per trap were $13.3 \%$ in 1983 and $15.5 \%$ in 1985 , respectively (se $=1.004$ and $s e=0.830$, respectively). The catch rate of marketable-size 052 cm fork length) sablefish followed a similar pattern, except it did not increase as sharply between 1981 and 1983 before dropping back to the 1981 level of abundance in 1985. The mean catch rate of submarketable-size sablefish increased from 2.7 fish per trap in the first 2 years, to 4.6 and 4.5 fish per trap in 1983 and 1985, respectively (Fig. 4). The proportion of submarketable-size sablefish has increased steadily from 24\% in 1979 to 59\% in 1985 (Table 2). Mean catch rates of small, medium, and large marketable-size sablefish are shown in Figure 5. Catch rates for all marketable-size groups were much lower in 1985 than in 1979, the baseline year. In 1985, mean catch rates of small sablefish were about 2.6 fish per trap, less than one-half the rate in 1979. Mean catch rates for medium and large sablefish were 0.3 and 0.2 fish per trap, down from 1.4 and 1.1 fish per trap, respectively, in 1979. Catch rates expressed in average number of pounds of sablefish captured per trap are shown in Figure 6; these catch rates show an even larger decrease in catch rates primarily due to the fact that average size continues to decline.

The length frequency distributions and mean lengths of sablefish captured in the first two sets at the four original sites off Oregon and Washington during the 1979 and 1985 surveys are shown in Figure 7 and for all survey years in Figure 8. The mean length dropped from 57 cm in 1979 to 52 cm in 1985 (Fig. 8). The 1985 length composition for all eight Oregon and Washington sites combined are shown in Figure 9. The sablefish captured at the four new sites were on


Figure 4. --Mean catch rates of all sablefish, submarketable-size sablefish (<52 cm fork length), and marketable-size sablefish (>52 cm fork length) at the four original index sites off Oregon and Washington 1979-85 and at the four new index sites in 1985. The sites were not sampled in 1982 or in 1984.

Table 2.--Average percentage abundance of submarketable-size and marketable-size sablefish at the four original Oregon and Washington abundance index sites combined, at the four new sites, and for all eight sites combined during the 1979-81, 1983, and 1985 surveys.

| Year and area | Submarketable ${ }^{\text {a }}$ (\%) | Marketable |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | $\text { Small } b$ <br> (\%). | $\begin{gathered} \text { Medium } \\ (\%) \end{gathered}$ | Large ${ }^{\text {d }}$ <br> (\%) | Total <br> (\%) |
| 1979 | 24 | 54 | 12 | 10 | 100 |
| 1980 | 37 | 47 | 8 | 8 | 100 |
| 1981 | 37 | 49 | 8 | 6 | 100 |
| 1983 | 44 | 45 | 7 | 4 | 100 |
| 1985 (Original sites) | 59 | 35 | 4 | 2 | 100 |
| 1985 (New sites) | 45 | 42 | 8 | 5 | 100 |
| 1985 (All eight sites) | 51 | 39 | 6 | 4 | 100 |

[^1]

Figure 5. --Mean catch rates of small, medium, and large sablefish at the four original index sites off Oregon and Washington 1979-85, and at the four new sites in 1985.


Figure 6. --Mean catch rates of sablefish in number of pounds per trap at the four original index sites off Oregon and Washington 1979-85 and at the four new sites in 1985. The sites were not sampled in 1982 or 1984 .


[^2]





Figure 8. --Length composition of sablefish (shown in percent) captured in the first two sets at the original sites off Oregon and Washington during the 1979 , 1980, 1981,1983 , and 1985 surveys.


Figure 9.--Sablefish length composition for all Oregon and Washington sites combined, August-September 1985.
the average slightly larger than those from the original sites, primarily due to the much larger sablefish captured at the Nitinat Canyon site.

Sablefish catches, length compositions, and mean length by depth for all sites sampled in 1985 are combined and shown in Figure 10. Catch rates were greatest at 225 and 300 fathoms, where mean lengths were smallest at 50.9 and 51.4 cm , respectively.

Length at Age
The validity of sablefish age determination has been under evaluation in recent years and the otoliths collected in 1983 and 1985 are the first of our samples to have been read since age determinations were resumed. Otolith surfaces were used in easy to read cases, while the break and burn procedure was used to read otoliths with unclear surface markings. The mean lengths at age (Table 3) are very similar between the 1983 and 1985 samples through age 7 (86-88\% of the fish aged) but are quite different in older ages. This difference may be related to the difficulty in obtaining consistent age determinations in older fish. Reader agreement was near $70 \%$ for sablefish aged 7 or less but decreased to $11-12 \%$ for older ages, indicating the low reliability of those readings. The von Bertalanffy $t_{0}$ parameters (Fig. 11) are relatively large, negative values indicating that both the 1983 and 1985 age-length curves do not describe long-term sablefish growth very well and are probably most accurate for ages 2 through 7. The departure of the curves for older fish (Fig. 11) likely reflects the relatively small numbers of older fish in the sample and low reader agreement on ages greater than 7 years. To enhance the sample size of large fish we selected stratified samples of larger sablefish in addition to random samples beginning in 1986.

The 1983 and 1985 sablefish year class and age frequencies are shown in Figure 12. These data indicate that the 1977 and 1979 year classes were


Table 3. --Mean length calculated from the von Bertalanffy curve and percent at age for sablefish captured during the 1983 and 1985 abundance index survey off Washington and Oregon.

|  | Males |  |  | Females |  |  | sexes combined |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Age in years | $\bar{L}(\mathrm{~cm})$ | \% | n | $\bar{L}(\mathrm{~cm})$ | \% | n | $\bar{L}(\mathrm{~cm})$ | 8 | n |

## 1983 SURVEY

| 2 | 46.0 | 4.1 | 9 | 45.7 | 4.9 | 16 | 45.4 | 4.6 | 25 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 3 | 48.8 | 20.3 | 44 | 50.9 | 7.7 | 25 | 50.0 | 12.7 | 69 |
| 4 | 51.0 | 25.8 | 56 | 54.8 | 33.4 | 110 | 53.4 | 30.2 | 166 |
| 5 | . 52.6 | 14.3 | 31 | 57.9 | 12.6 | 41 | 56.0 | 13.3 | 72 |
| 6 | 53.8 | 13.4 | 29 | 60.2 | 20.2 | 68 | 57.9 | 17.5 | 97 |
| 7 | 54.7 | 5.1 | 11 | 62.0 | 8.9 | 29 | 59.3 | 7.4 | 40 |
| 8 | 55.4 | 3.7 | 8 | 63.4 | 3.1 | 10 | 60.3 | 3.3 | 18 |
| 9 | 55.9 | 2.8 | 6 | 64.5 | 2.1 | 7 | 61.1 | 2.4 | 13 |
| 10 | 56.3 | 5.5 | 12 | 65.3 | 0.3 | 1 | 61.7 | 2.4 | 13 |
| 11 | 56.6 | 1.8 | 4 | 65.9 | 1.8 | 7 | 62.1 | 1.8 | 11 |
| 12 | 56.8 | 0.9 | 2 | 66.4 | 2.1 | 7 | 62.4 | 1.7 | 9 |
| 13 | 57.0 | -- | -- | 66.8 | 0.6 | 2 | 62.6 | 0.4 | 2 |
| 14 | 57.1 | - | - | 67.1 | 0.6 | 2 | 62.8 | 0.4 | 2 |
| 15 | 57.2 | 0.5 | 1 | 67.3 | 1.2 | 4 | 62.9 | 0.9 | 5 |
| 16 | 57.3 | 0.9 | 2 | 67.5 | - | -- | 63.0 | 0.4 | 2 |
| 17 | 57.4 | -- | - | 67.6 | -- | - | 63.1 | -- | -- |
| 18 | 57.4 | -- | -- | 67.7 | -- | -- | 63.2 | -- | - |
| 19 | 57.4 | 0.5 | 1 | 67.8 | -- | -- | 63.2 . | 0.2 | 1 |
| 20 | 57.5 | -- | -- | 67.8 | -- | -- | 63.2 | -- | - |
| 21 | 57.5 | -- | -- | 67.9 | -- | -- | 63.2 | -- | -- |
| 22 | 57.5 | 0.5 | 1 | 67.9 | -- | -- | 63.3 | 0.2 | 1 |
| 23 | $\rightarrow$ | -- | -- | 67.9 | 0.3 | 1 | -- | 0.3 | 1 |
| Total |  |  | 217 |  |  | 330 |  |  | 547 |

1985 SURVEY

| 2 | 44.5 | 3.8 | 26 | 45.6 | 7.9 | 44 | 45.3 | 5.7 | 70 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 3 | 47.4 | 11.5 | 76 | 49.8 | 15.3 | 85 | 48.6 | 13.2 | 161 |
| 4 | 49.9 | 17.8 | 118 | 53.4 | 19.1 | 107 | 51.4 | 18.4 | 225 |
| 5 | 52.1 | 23.3 | 154 | 56.6 | 16.8 | 93 | 54.0 | 20.3 | 247 |
| 6 | 54.0 | 18.3 | 121 | 59.5 | 20.0 | 101 | 56.3 | 19.1 | 232 |
| 7 | 55.7 | 12.9 | 85 | 61.9 | 8.6 | 46 | 57.8 | 10.9 | 131 |
| 8 | 57.2 | 5.8 | 39 | 64.1 | 5.0 | 28 | 58.3 | 5.4 | 67 |
| 9 | 58.5 | 3.2 | 23 | 66.0 | 2.2 | 13 | 61.8 | 2.7 | 36 |
| 10 | 59.6 | 0.8 | 5 | 67.7 | 1.4 | 9 | 63.2 | 1.1 | 14 |
| 11 | 60.6 | 1.5 | 12 | 69.1 | 1.1 | 7 | 64.5 | 1.3 | 19 |
| 12 | 61.5 | 0.6 | 5 | 70.4 | 0.9 | 5 | 65.6 | 0.7 | 10 |
| 13 | 62.2 | 0.3 | 2 | 71.5 | 0.9 | 5 | 66.6 | 0.6 | 7 |
| 14 | 62.9 | 0.3 | 2 | 72.5 | 0.4 | 2 | 67.5 | 0.3 | 4 |
| 15 | - | -- | -- | 73.4 | -- | -- | -- | - | - |
| 16 | - | -- | -- | 74.1 | 0.2 | 1 | -- | 0.1 | 1 |
| 17 | - | -- | -- | 74.8 | -- | - | -- | -- | -- |
| 18 | -- | -- | -- | 75.4 | -- | -- | -- | -- | -- |
| 19 | -- | -- | -- | 75.9 | -- | -- | -- | -- | -- |
| 20 | - | -- | -- | 76.3 | -- | - | -- | -- | -- |
| 21 | -- | -- | - | 76.7 | -- | -- | -- | -- | - |
| 22 | - | - | - | 77.1 | -- | -- | -- | -- |  |
| 23 | -- | -- | -- | 77.4 | 0.2 | 1 | -- | 0.1 | 1 |
| Total ( $n$ ) |  |  | 668 |  |  | 557 |  |  | 1225 |



Figure 11 .--Calculated age-length curves based on the von Bertalanffy growth function, $L=L$, [1-e $\left.e^{-k}(t-t),\right]$ (Ricker 1975: equation 9.9) for sablefish captured off Washington and Oregon in 1983 and 1985.


Figure 12. --Sablefish year-class frequency and age frequencies from random otolith samples collected during the 1983 and 1985 index surveys off Oregon and Washington.
strong in our 1983 sample; however, the strength of both of these year classes was less apparent in our 1985 sample. Recent strong year classes are not apparent, although the 1982 and 1983 year classes were not yet fully recruited and therefore may not be adequately represented.

Juvenile sablefish were first recruited to our sampling gear at an age of $2+$ and $3+$ and at an average length of about $44-50 \mathrm{~cm}$. Submarketable-size sablefish, primarily from the 1981, 1982, and 1983 year classes, comprised about one-half of the fish captured during the 1985 survey (Tables 2 and 3). At approximately 4-5 years of age, sablefish reach marketable size (>51 cm). Approximately $87 \%$ of the 1985 age sample was 7 years old or less (Table 3). Length-Weight Relationship

The length-weight by sex relationship was examined by regression, but males and females could not be distinguished graphically and differences were statistically insignificant. Sasaki (1985) also found no distinguishing differences between the length-weight relationships of male and female sablefish in the Bering Sea and North Pacific Ocean. Therefore, data for sexes are combined and presented in Figure 13. The predicted weight values by l-cm intervals are shown in Table 4. The length-weight relationship is $W$ $=.00366 \mathrm{x}^{3} \mathrm{~L}^{24316}$, where $\mathrm{W}=$ weight in grams and $L=$ length in centimeters.

Length at 50\% Maturity
A probit analysis (Finney 1971) was used to calculate length at $50 \%$ maturity for the 701 male and 569 female sablefish sampled in 1985. Results indicate that $50 \%$ maturity is reached at 50.8 cm for males and 55.3 cm for females. When compared to sablefish taken off northern California (Bodega Canyon) from 1980 to 1982 (Parks and Shaw 1983), length at 50\% maturity for Washington and Oregon samples was 2 cm less for males (52.7) and identical


Figure 13.--Length-weight relationship derived from sablefish collected off Washington and Oregon in August-September 1985.

Table 4 .--Predicted mean weights by l-cm length intervals for sablefish (sexes combined) captured off Oregon and Washington in AugustSeptember 1985.

| Leng th <br> (cm) | Mean weight ( g ) | Weight <br> (1b) | Length (cm) | Mean weight (g) | Weight <br> (lb) |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 35 | 373 | 0.82 | 70 | 3,533 | 7.79 |
| 36 | 409 | 0.90 | 71 | 3,699 | 8.15 |
| 37 | 447 | 0.99 | 72 | 3,870 | 8.53 |
| 38 | 487 | 1.07 | 73 | 4,048 | 8.92 |
| 39 | 530 | 1.17 | 74 | 4,230 | 9.33 |
| 40 | 575 | 1.27 | 75 | 4,418 | 9.74 |
| 41 | 623 | 1.37 | 76 | 4,612 | 10.17 |
| 42 | 674 | 1.49 | 77 | 4,812 | 10.61 |
| 43 | 727 | 1.60 | 78 | 5,018 | 11.06 |
| 44 | 784 | 1.73 | 79 | 5,229 | 11.53 |
| 45 | 843 | 1.86 | 80 | 5,447 | 12.01 |
| 46 | 905 | 2.00 | 81 | 5,671 | 12.50 |
| 47 | 971 | 2.14 | 82 | 5,901 | 13.01 |
| 48 | 1,039 | 2.29 | 83 | 6,138 | 13.53 |
| 49 | 1,111 | 2.45 | 84 | 6,381 | 14.07 |
| 50 | 1,186 | 2.62 | 85 | 6,631 | 14.62 |
| 51 | 1,265 | 2.79 | 86 | 6,886 | 15.18 |
| 52 | 1,347 | 2.97 | 87 | 7,150 | 15.76 |
| 53 | 1,433 | 3.16 | 88 | 7,420 | 16.36 |
| 54 | 1,523 | 3.36 | 89 | 7,697 | 16.97 |
| 55 | 1,616 | 3.56 | 90 | 7,981 | 17.60 |
| 56 | 1,713 | 3.78 | 91 | 8,272 | 18.24 |
| 57 | 1,814 | 4.00 | 92 | 8,571 | 18.90 |
| 58 | 1,920 | 4.23 | 93 | 8,877 | 19.57 |
| 59 | 2,029 | 4.47 | 94 | 9,190 | 20.26 |
| 60 | 2,143 | 4.72 | 95 | 9,511 | 20.97 |
| 61 | 2,251 | 4.98 | 96 | 9,839 | 21.69 |
| 62 | 2,383 | 5.25 | 97 | 10,176 | 22.43 |
| 63 | 2,510 | 5.53 | 98 | 10,520 | 23.19 |
| 64 | 2,642 | 5.82 | 99 | 10,872 | 23.97 |
| 65 | 2,778 | 6.12 | 100 | 11,232 | 24.76 |
| 66 | 2,929 | 6.43 |  |  |  |
| 67 | 3,065 | 6.76 |  |  |  |
| 68 | 3,216 | 7.09 |  |  |  |
| 69 | 3,372 | 7.43 |  |  |  |

for females (55.3). Mason et al. (1983) reported that length at 50\% maturity was approximately 52 cm for males and 58 cm for females off the west coast of Canada. Sasaki (1985) found that $50 \%$ of the male sablefish reach maturity at 57 cm and $50 \%$ of the females at 65 cm in the Gulf of Alaska.

## SUMMARY AND CONCLUSIONS

Survey catch rates indicate that sablefish abundance off Oregon and Washington decreased between 1979 and 1981, increased between 1981 and 1983, and then dropped back to a point midway between 1979 and 1981 population levels in 1985 (Fig. 4). Total sablefish catch rates have declined from 11.4 fish per trap in 1979 to 7.6 fish per trap in 1985, indicating a decrease in sablefish abundance of about $33 \%$. The 1985 catches at the four original sites were composed of a much higher percentage of submarketable-size sablefish (59\%) and a much lower percentage of medium and large marketable sablefish (4 and 2\%, respectively) than in any of the previous surveys. Size composition at seven of the eight sites sampled in 1985 was similar. Fish captured at the Nitinat Canyon site adjacent to the Canadian Fishery Zone were much larger, although fewer in number (Appendix Table 2 and Appendix Fig. 3).

Apparently, fishing and natural mortality have reduced the numbers of larger sablefish off Oregon and Washington since 1979, while at the same time recruitment of primarily 3-year-old sablefish into the fishery has increased the proportion of smaller-size sablefish. Some fishermen reported that they were catching significant quantities of larger sablefish in depths greater than those covered in our standard survey (150-450 fathoms). Deepwater sets made in 525 fathoms off Washington during our 1985 survey resulted in catch rates higher than at all depths except 300 fathoms (Fig. 10). The distribution of sablefish in the deeper portions of its bathymetric range requires further
study and sampling in 525-700 fathoms is planned for future surveys. There is little doubt that the mean size of sablefish has continued to decline off the coast of Oregon and Washington and the data indicate that submarketable-size fish now make up a very high percentage of the sablefish stocks.

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ACKNOWLEDGMENTS


#### Abstract

We acknowledge Charles D. Knechtel, operations research analyst, with the Resource Assessment and Conservation Engineering Division of the Northwest and Alaska Fisheries Center (NWAFC), for his statistical analysis of the sablefish catches by trap type, and for his tests for significance between catch rates by year. Also, we acknowledge the NWAFC Age Reading Unit for their work in ageing the 1983 and 1985 sablefish otolith samples.


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Appendix Table 1. --Catch rates of total sablefish and submarketable, marketable, small, medium, and large sablefish taken in the first two sets at Washington and Oregon abundance index sites by year. Average number per trap is the estimated mean number of sablefish captured per conical trap unit based on the relative efficiencies of conical and rectangular traps observed in 1985.


Appendix Table 2.--Percentage abundance of submarketable-size and marketable-size sablefish in samples from four original Oregon and Washington abundance index sites combined during the 1979-81, 1983, and 1985 surveys, and the four new sites in 1985.

| Year and area |  | SubMarketable ${ }^{\text {a }}$ <br> (응) | Marketable |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Small ${ }^{b}$ <br> (\%) | Medium ${ }^{\text {c }}$ <br> (\%) | Larged <br> (\%) | $\begin{gathered} \text { Total } \\ (\%) \end{gathered}$ |
| 1979 |  |  |  |  |  |  |
|  | Cape Arago |  | 24 | 54 | 12 | 10 | 76 |
|  | Cape Lookout | 19 | 57 | 13 | 11 | 81 |
|  | Willapa Bay | 35 | 51 | 7 | 7 | 65 |
|  | Cape Johnson | 20 | 55 | 13 | 12 | 80 |
|  | Average | 24 | 54 | 12 | 10 | 76 |
| 1980 |  |  |  |  |  |  |
|  | Cape Arago | 47 | 39 | 8 | 6 | 53 |
|  | Cape Lookout | 38 | 44 | 9 | 9 | 62 |
|  | Willapa Bay | 31 | 52 | 8 | 9 | 69 |
|  | Cape Johnson | 31 | 54 | 8 | 7 | 69 |
|  | Average | 37 | 47 | 8 | 8 | 63 |
| 1981 |  |  |  |  |  |  |
|  | Cape Arago | 47 | 44 | 6 | 3 | 53 |
|  | Cape Lookout | 29 | 46 | 12 | 13 | 71 |
|  | Willapa Bay | 34 | 52 | 7 | 7 | 66 |
|  | Cape Johnson | 39 | 52 | 6 | 3 | 61 |
|  | Average | 37 | 49 | 8 | 6 | 63 |
| 1983 |  |  |  |  |  |  |
|  | Cape Arago | 43 | 49 | 5 | 3 | 57 |
|  | Cape Lookout | 39 | 47 | 8 | 6 | 61 |
|  | Willapa Bay | 44 | 44 | 7 | 5 | 56 |
|  | Cape Johnson | 48 | 42 | 7 | 3 | 52 |
|  | Average | 44 | 45 | 7 | 4 | 56 |
| 1985 |  |  |  |  |  |  |
|  | Cape Arago | 59 | 39 | 1 | 1 | 41 |
|  | Cape Lookout | 55 | 37 | 6 | 2 | 45 |
|  | Willapa Bay | 57 | 34 | 5 | 4 | 43 |
|  | Cape Johnson | 64 | 30 | 3 | 3 | 36 |
|  | Average | 59 | 35 | 4 | 2 | 41 |
|  | (New sites) |  |  |  |  |  |
|  | Yaquina Bay | 45 | 44 | 8 | 3 | 55 |
|  | Tillamook Head | 65 | 29 | 3 | 3 | 35 |
|  | Cape Elizabeth | 54 | 34 | 6 | 6 | 46 |
|  | Nitinat Canyon | 13 | 62 | 16 | 9 | 87 |
|  | Average | 45 | 42 | 8 | 5 | 55 |
|  | All eight sites Average | s 51 | 39 | 6 | 4 | 49 |

[^3]

## WILLAPA BAY











Fork length (cm)

Appendix Figure 2. --Length composition of sablefish captured at the Willapa Bay and Cape Johnson, Washington, sites during the 1979-81, 1983, and 1985 index surveys. Vertical line (a) is the division between submarketable-size and marketable-size sablefish, and vertical line (b) is the mean length.


Fork length (cm)

> Appendix Figure 3. --Length composition of sablefish, captured at the Yaquina Bay and Tillamook Head, Oregon, and-Cape Elizabeth and Nitinat Canyon, Washington, sites in the 1985 index survey. Vertical line (a) is the division between submarketable-size and marketable-size sablefish, and vertical line (b) is the mean length.


[^0]:    Figure 2. --Catch of sablefish in conical traps versus catch of sablefish in rectangular traps off Washington and Oregon, August-September 1985. Each data point represents the average catch of five conical and five rectangular traps on a single longline.

[^1]:    a less than 52 cm fork length $=$ less than 3.0 lb round weight
    b 52-61 cm fork length $=3.0-5.0 \mathrm{lb}$ round weight
    c 62-67 cm fork length $=5.0-7.0 \mathrm{lb}$ round weight
    d 68 cm or greater fork length $=$ more than 7.0 lb round weight

[^2]:    Figure 7. --Combined length composition of sablefish (shown in percent) captured in the first two sets at the four original sites off Oregon and Washington during the 1979 and 1985 surveys.

[^3]:    a less than 52 cm fork length = less than 3.0 lb round weight
    b 52-61 cm fork length $=3.0-5.0 \mathrm{lb}$ round weight
    c $62-67 \mathrm{~cm}$ fork length $=5.0-7.0 \mathrm{lb}$ round weight
    d 68 cm or greater fork length $=$ more than 7.0 lb round weight

