FECUNDITY OF SABLEFISH, *ANOPLOPOMA FIMBRIA*, FROM OREGON COASTAL WATERS

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ABSTRACT

During November–December 1988 and February–March 1989, sablefish females were collected off Oregon's coast. Potential annual fecundity for a 2.5 kg sablefish female (without ovary) was about 276,000 oocytes, or 110 oocytes per gram of weight. The annual stock of oocytes is spawned in three or four batches. The ovaries of sablefish used to estimate potential annual fecundity showed no histological evidence of past spawning. The maturity window for estimating annual fecundity of sablefish was determined to be when the average diameters of advanced-yolked oocytes between 0.74 mm and 1.17 mm. Atretic losses of advanced-yolked oocytes were detected, but they seemed to have little effect on potential annual fecundity of the population. Fifty percent of the females off Oregon's coast (November–December 1988) were sexually mature when they reached 548 mm in fork length.

RESUMEN

Se colectaron hembras del bacalao negro frente a la costa de Oregon en Noviembre–Diciembre de 1988 y Febrero–Marzo de 1989. La fecundidad anual potencial de un bacalao negro hembra de 2.5 kg (sin ovarios) fué de 276,000 ovocitos, o 110 ovocitos por gramo de peso. El stock anual de ovocitos se desova en 3 o 4 puestas. Los ovarios usados para estimar la fecundidad potencial anual no mostraron evidencia histológica de desoves previos. Se determinó que el periodo de madurez oportuno para estimar la fecundidad anual es cuando el diámetro promedio de un ovocito en estado de vitelo avanzado es de entre 0.74 y 1.17 mm. Se observaron pérdidas de ovocitos en estado de vitelo avanzado con condición de atresia, pero las pérdidas parecieron tener poco impacto en la fecundidad anual de la población. El 50% de las hembras frente a la costa de Oregon (Noviembre–Diciembre, 1988) se encontraban sexualmente maduras cuando alcanzaron una longitud furcal de 548 mm.

INTRODUCTION

The annual fecundity of sablefish, *Anoplopoma fimbria*, appears to be determinate; that is, the stock of advanced-yolked oocytes before spawning is equivalent to the potential annual fecundity (Hunter et al. 1989). The other extensive measure of potential annual fecundity of sablefish comes from Mason (1984), who studied fish from off British Columbia, Canada. Other studies of sablefish reproduction include those by Phillips and Imamura (1954), Mason et al. (1983), Norris et al. (1987), Cailliet et al. (1988), and Fujiwara and Hankin (1988). The main objective of the study reported here was to estimate the potential annual fecundity for sablefish captured off the Oregon coast.

Estimates of potential annual fecundity depend upon four key assumptions: (1) fecundity is determinate; (2) oocytes are identifiable and fully recruited into the advanced stock; (3) the females have not spawned; and (4) potential fecundity estimated early in the season is nearly the same as the actual annual fecundity. In this paper, we review past evidence for determinate fecundity provided by Hunter et al. (1989) and, for the first time, evaluate assumptions 3 and 4. In addition, we use data from Oregon and central California to update the present information on spawning rates and batch fecundity, and we provide an estimate of the length at which 50% of the Oregon females are mature.

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METHODS

Sablefish were collected in bottom trawls off Oregon's coast between Heceta Head and Cape Lookout (appendix table A) as part of two cooperative groundfish research surveys made in 1988–1989 by the Alaska Fisheries Science Center's (AFSC) Resource Assessment and Conservation Engineering Division, the Southwest Fisheries Science Center's (SWFSC) Coastal Fisheries Resource Division, and the SWFSC Tiburon Laboratory. The trawl used was either an AFSC-modified 5-inch mesh, 90/120, high-rise "poly Nor'Eastern" bottom trawl (fishing dimensions: ~4.6 m high and 13.5 m wide at wing tips), or a 5½-inch mesh, 75/90, high-rise Aberdeen bottom trawl. Trawls were towed on the bottom for 0.5 hour at depths shallower than 732 meters (400 fathoms) and for 1 hour at depths from 732 to 1,247 meters.

In both surveys, the total catch of sablefish in each haul was weighed. A random subsample of up to 100 sablefish was sexed and measured to the nearest millimeter (fork length). Ovaries were assigned to one of three classes: no yolked oocytes present, yolked oocytes present, or translucent (hydrated) oocytes present.

Some fish, immediately after capture, were weighed to the nearest gram because their otoliths were saved (in 50% ethanol) or because ovarian tissue was removed and preserved. Females selected for ovarian preservation were taken randomly from the trawl catch; the whole ovary was preserved only when it contained yolked or hydrated oocytes. Any remaining sablefish not individually weighed in the random sample were grouped (male, active female, or inactive female), and the groups were weighed to the nearest pound. Individual weights were added to group weights to provide the combined total weight and number of individuals per reproductive class (appendix table B).

Ovaries with hydrated oocytes or other yolked oocytes were considered to be reproductively active and sexually mature, whereas ovaries in which observers saw no yolked oocytes were considered to be inactive (not capable of spawning at the time of capture or in the near future). To estimate size at maturity (length at 50% mature), inactive ovaries were considered sexually immature, since we used only specimens taken early in the spawning season (November–December 1988). We calculated the fraction of active ovaries for each fork length class (in 50 mm increments). Size at maturity was estimated by means of logistic regression (BMDPLR, Dixon et al. 1988).

Ovarian tissue samples and whole ovaries were preserved in 10% neutral buffered Formalin, and whole ovaries were subsequently weighed to the nearest 1/100 gram in the laboratory. A piece of each sablefish ovary was dehydrated and embedded in paraffin. Histological sections were cut at 5–6 μm and stained with Harris hematoxylin, followed by eosin counterstain (H&E). Each ovary was classified histologically in the manner developed for northern anchovy, *Engraulis mordax*, by Hunter and Goldberg (1980) and Hunter and Macewicz (1980, 1985a, b), with a few modifications appropriate for sablefish ovarian structure (Hunter et al. 1989). In the ovary, we identified the presence or absence of the following: oocytes in the first vitellogenic stages, advanced-yolked oocytes, migratory-nucleus-stage oocytes (precursor to hydration), hydrated oocytes, postovulatory follicles, and two stages of atresia (α and β). The rate at which postovulatory follicles degenerate and are absorbed in sablefish is unknown, so we did not assign ages to postovulatory follicles. At the end of the season, spent ovaries usually contained two groups of postovulatory follicles, distinguished by differences in their degree of deterioration, which indicated two past spawnings. Postovulatory follicles in one group were small, and the extent of their resorption indicated that they were older than 48 hours because in northern anchovy (Hunter and Macewicz 1985a) and chub mackerel (Dickerson et al. 1992) postovulatory follicles reach this stage of deterioration in 48 hours at habitat temperatures about 10°C higher than temperatures in the sablefish habitat.

Total fecundity (F_T) is defined as the total number of advanced-yolked oocytes in the ovary, including all hydrated oocytes. We estimated total fecundity gravimetrically: fecundity (F_T) is the product of the gonad weight (G) and oocyte density (C). Oocyte density is the number of oocytes per gram of ovarian tissue and is determined by counting the number of advanced oocytes in a weighed sample of ovarian tissue. Hunter et al. (1989) found no difference in oocyte density between the right and left ovary in sablefish off central California. They defined advanced-yolked oocytes as those in which the yolk is dense enough to occlude, or reduce, the visibility of the nucleus when the oocyte is viewed on a video screen; most of the oocytes larger than 0.6 mm in diameter met this criterion. We removed two tissue samples from the right ovary and counted all the advanced-yolked oocytes in both weighed samples.

In one of the samples, we also measured the diameter of 30 randomly selected (nonhydrated) advanced-yolked oocytes, to determine mean diameter of the advanced oocyte stock. Mean diameter of advanced oocytes (exclusive of hydrated oocytes) is a measure of the extent of yolking of the advanced oocytes in the ovary and, as a consequence, is an index of a female's readiness to hydrate and spawn a batch. The mean diameter is not an accurate measure of the degree of yolking if hydrated oocytes are included in the measurement. Advanced oocytes were identified, counted, and measured with a digitizer linked to a personal computer and a video camera system mounted on a dissection microscope.

Of sablefish captured off Oregon in November–December 1988, we estimated total fecundity for 130 active females containing advanced oocytes. Histological analysis of the ovaries indicated that three females had spawned already (postovulatory follicles present) and one female had extensive α atresia of yolked oocytes (≥50%); these four females were not used for analysis of potential annual fecundity but were used for other analyses. Near the end of the spawning season off Oregon (March 1989), we used 12 females with active ovaries for estimating total fecundity (appendix table C).

The number of hydrated oocytes in an ovary is equivalent to the batch fecundity (F_B), that is, the number of oocytes released during one spawning. Hydrated oocytes are easily identified because of their large diameter (about 2 mm) and translucent appearance. We estimated batch fecundity by counting the number of hydrated oocytes in two tissue samples per ovary. We estimated the number of nonhydrated advanced oocytes present in the same ovary by using the procedure described for estimating total fecundity. None of the ovaries collected in 1988 had hydrated oocytes. In 1989, 11 females with ovaries containing hydrated oocytes were taken, but 9 of these had begun spawning and were not suitable for estimating batch fecundity. Total fecundity (F_T) for females with hydrated ovaries is the sum of the hydrated and advanced-yolked oocytes.

To measure atretic losses anatomically (whole oocyte method), we counted the number of atretic oocytes (α atresia of advanced-yolked oocytes) occurring in the random sample of 30 advanced-yolked oocytes for each female for which we estimated a total fecundity. For Formalin-preserved ovaries, we also estimated the amount of α atresia of the advanced-yolked oocytes in a section of the ovary on the H&E slide (histological method) and grouped the ovaries into three classes by incidence of α (none; $0 < \alpha < 50\%$ of the advanced-yolked oocytes; and $\alpha \geq 50\%$ of the advanced-yolked oocytes).

RESULTS AND DISCUSSION

Maturity Window

An optimal range of ovarian maturity (a maturity window) exists for counting the oocytes constituting the potential annual fecundity (Hunter et al. 1992). If one counts the advanced stock of oocytes too early in the maturation period, not all of the oocytes destined to become part of the annual stock will be recruited. But if one counts too late, some oocytes may have been lost due to spawning. Other than the presence of hydrated or migratory-nucleus-stage oocytes, the best indicator of a female's readiness to spawn is the average diameter of the oocytes making up the advanced stock (Hunter et al. 1989). Thus the average diameters of the advanced, nonhydrated oocytes can be used to define the upper and lower bounds of the maturity window.

The diameter of the (nonhydrated) advanced-yolked oocytes of sablefish increases steadily during early maturation, and it continues to increase well into the spawning season (Hunter et al. 1989). Thus if oocytes are being recruited into the advanced stock, total fecundity would be expected to increase with mean oocyte diameter and would be positively correlated, whereas if spawning has begun, fecundity would be expected to decrease with mean oocyte diameter and would be negatively correlated. This point is illustrated diagrammatically for a single female in figure 1.

Hunter et al. (1989) examined the lower bound of the maturity window and concluded that, in sablefish, all oocytes were probably recruited into the advanced stock by the time their average diameter was above 0.7 mm, when the separation of the advanced mode was nearly complete. This conclusion was based on visual inspection of the oocyte frequency distributions of six sablefish ovaries. Since nearly all the ovaries of the active sablefish females analyzed from November–December

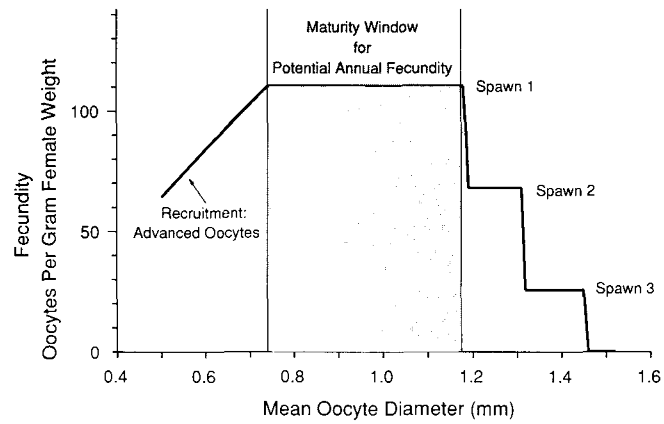

Figure 1. Hypothetical cycle of oocyte maturation in a single female, showing initial maturation of oocytes and the subsequent loss of oocytes due to spawning. The hydrations of oocytes are not indicated (these would be brief events just before each spawning). The diagram indicates changes in the standing stock of advanced oocytes (exclusive of hydrated oocytes) as a function of their average diameter. The diagram begins after some oocyte maturation has occurred, when the diameter of the advanced stock averages 0.5 mm (a condition probably prevalent in late summer or early fall in Oregon); the diagram ends after all advanced oocytes are spawned. The level segment of the line is the maturity window, a range of average oocyte diameters where estimates of the potential annual fecundity can be made without bias from oocyte recruitment or spawning losses. The maturity window for most, but not all, Oregon females occurs in early December.

1988 were well developed, 0.74 mm was set as the lower maturity bound for females to be included in the estimation of potential annual fecundity, because it was the smallest observed mean diameter above 0.7 mm for the advanced oocyte stock (appendix table C). There were too few females with ovaries containing mean oocyte diameters of the advanced stock between 0.6 mm and 0.9 mm to permit a quantitative analysis of oocyte recruitment such as the one carried out for Dover sole by Hunter et al. (1992).

The upper bound of the maturity window is the level of ovarian maturity (mean diameter of the advanced oocytes) at which spawning and oocyte losses begin. Multiple regression analysis indicated that ovaries of some sablefish taken in November–December 1988 exceeded the upper limit of the maturity window. The evidence was that total fecundity was negatively correlated with mean diameter of the advanced oocytes as well as being correlated with female weight (table 1). To determine the upper bound of the maturity window, we conducted a series of stepwise multiple regression analyses by successively removing data by 0.01 mm decrements of mean oocyte diameter, starting with the largest class (1.38 mm). This analysis indicated that the threshold for a significant effect of diameter on total fecundity was between mean oocyte diameters of 1.17 mm and 1.18 mm (table 2). The multiple regression coefficient for oocyte diameter was negative and significant when females containing ovaries with mean oocyte diameters equal to or larger than 1.18 mm were included, but insignificant when

TABLE 1
Total Fecundity (F_T) of Sablefish, *Anoplopoma fimbria*, and Female Weight (W, without Ovary) and the Average Diameter of the Advanced Oocytes (D) Based on Stepwise Regression with Analysis of Variance

Stepwise regression		
Step	1	2
Constant	−147,802	56,461
Weight (W)	162.1	163.9
t*	22.49	23.42
Diameter (D)		−192,244
t*		−3.07
S	89,416	86,518
r^2	80.31	81.72

Analysis of variance					
Source	D.F.	SS	MS	F	P
Regression	2	4.11×10^{12}	2.06×10^{12}	274.87	< 0.001
Error	123	9.21×10^{11}	7.85×10^{9}		
Total	125	5.04×10^{12}			
Source	D.F.	Sequential SS			
Weight	1	4.04×10^{12}			
Diameter	1	7.70×10^{10}			

*For $P = 0.005$, $2.860 < t < 2.807$, d.f. ≥ 120.
Specimens from off Oregon November–December 1988.

only those having a diameter of 1.17 mm or less were considered. Thus the upper bound of the maturity window for estimating potential annual fecundity using our multiple regression method is 1.17 mm (mean diameter of the advanced oocyte stock).

We also used a spawning-rate index (fraction of all active females having ovaries containing postovulatory follicles, hydrated oocytes, or migratory nucleus oocytes) to examine the upper bound of the maturity window. When the index was calculated for each 0.1 mm interval of mean oocyte diameter, the index increased from 0 to 0.027 (1/31) at a diameter of 1 mm, and reached 0.11 (5/46) at a diameter of 1.2 mm (figure 2, lower panel). Thus about 10% of active females had ovaries showing histological signs of past or imminent spawning when the advanced but nonhydrated oocytes averaged 1.2 mm diameter. Of course no female showing signs of past or imminent spawning would ever be used in our estimate of potential annual fecundity. The maturity window question under discussion is: What fraction of the fecundity data should be discarded because it may contain females that spawned undetected by our histological analysis?

Depending on the criteria, the upper bound of the window varies between 1.0 mm (spawning activity detected in 2.7% of population) to 1.2 mm (11% of the population). These estimates are similar to the one based on multiple regression of 1.18-mm diameter. We prefer the multiple regression method because it provides a well-defined selection criterion, deals directly with fecundity decrements, and takes into account the fecundity of all females.

Estimate of Potential Annual Fecundity

An important aspect of this paper and of an earlier paper on Dover sole (Hunter et al. 1992) is that accu-

TABLE 2
Results of Stepwise Multiple Regression of the Total Fecundity (F_T) of Sablefish, *Anoplopoma fimbria*, on Female Weight (W, without Ovary) and Mean Oocyte Diameter (D) for a Succession of Oocyte Diameter-Classes with the Model $F_T = a + b_1W + b_2D$

Oocyte diameter class (mm)	Sample size N	Constant a	Female weight b_1	Female weight t	Oocyte diameter b_2	Oocyte diameter t*	r^2
0.74–1.38	126	56,461	163.9	23.42	−192,244	−3.07	0.817
0.74–1.31	125	38,781	164.0	23.49	−175,403	−2.75	0.819
0.74–1.26	120	55,083	160.2	18.77	−181,762	−2.64	0.753
0.74–1.24	116	51,841	161.4	18.44	−181,595	−2.50	0.751
0.74–1.22	113	78,566	159.6	17.77	−203,843	−2.72	0.743
0.74–1.20	104	46,489	165.7	18.49	−187,223	−2.42	0.772
0.74–1.18	95	45,728	165.2	17.86	−185,199	−2.18	0.776
0.74–1.17	89	32,608	166.2	16.44	−174,357	−1.86	0.759
0.74–1.16	85	36,894	163.9	15.87	−172,557	−1.74	0.754
0.74–1.14	81	16,431	163.6	15.39	−150,338	−1.42	0.753
0.74–1.12	75	12,267	165.0	15.77	−149,791	−1.40	0.776
0.74–1.10	65	16,517	165.6	14.96	−156,029	−1.26	0.783
0.74–1.08	56	−13,905	172.4	14.06	−141,132	−0.97	0.793
0.74–1.06	49	−112,959	178.8	15.16	−49,071	−0.33	0.839
0.74–1.04	45	−212,363	180.3	14.75	57,923	0.37	0.845
0.74–1.02	36	−195,118	168.7	8.71	69,487	0.36	0.712
0.74–1.00	30	−321,284	171.2	8.22	208,859	0.90	0.738

*For $P = 0.05$, t is 1.979 for d.f. = 125, 1.987 for d.f. = 88, and 2.014 for d.f. = 45.
Specimens taken along Oregon coast November–December 1988. Line separates oocyte diameter-classes where diameter is a significant variable from those where it is not.

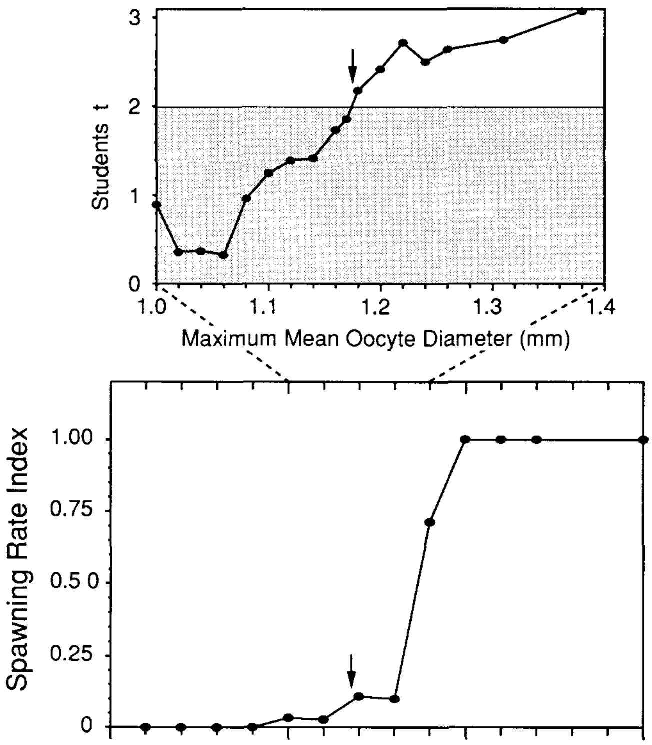

Figure 2. *Upper panel,* Student's $|t|$ as a function of maximum mean oocyte diameter from stepwise multiple regression analyses of fecundity as a function of female weight and oocyte diameter for Oregon sablefish taken during November–December 1988. When $|t| \geq 2$, the mean oocyte diameter has a significant negative correlation with fecundity, indicating a loss of oocytes from the advanced oocyte stock. *Lower panel,* Spawning rate index as a function of oocyte diameter: index = 0 when no females show signs of past or imminent spawning; index = 1 when all females show one of these signs. Arrow indicates point (1.17 mm) selected as the upper bound of the maturity window for estimating potential annual fecundity.

rate estimates of potential annual fecundity are much more difficult to make than is generally believed. A female sablefish was considered to be suitable for estimation of potential annual fecundity when the mean diameter of the advanced-yolked oocytes fell within the boundaries of the maturity window we have described (0.74–1.17 mm). In addition, females must also show no histological evidence of recent, past, or imminent spawning (no postovulatory follicles or hydrated oocytes within their ovaries) to be included in our estimate of potential annual fecundity.

Using only specimens that met these specifications, we regressed total fecundity on female weight (without ovary) for female sablefish captured off Oregon during November–December 1988; also using these specifications, we reevaluated the females from off central California (Hunter et al. 1989). The two linear regression equations for females from off central California and Oregon were quite similar (table 3). When the data were truncated so that the range in female weight was about the same for both regions, an analysis of covariance indicated that neither the difference of the intercepts between regions ($F_{1,\,108} < 0.001$, $P = 0.992$) nor the difference between slopes ($F_{1,\,108} = 0.15$, $P = 0.701$) was statistically significant. Combining all data, we obtained the following general equation:

$$Y_F = -126{,}654 + 161.2W$$

where Y_F is the estimated potential annual fecundity from the regression line, and W is female weight in grams without the ovary (figure 3). Thus the potential annual fecundity of a 2.5 kg sablefish female is about 276,000 oocytes (table 3), which is equivalent to about 110 oocytes per gram of female weight.

Mason et al. (1983) and Mason (1984) estimated the fecundity of sablefish taken off British Columbia, Canada. They used an exponential model and expressed fecundity (F) as a function of fork length (L, in cm). Both papers dealt with the same data, but showed small differences in the coefficients for the fecundity equation. We used the equation from Mason 1984, because that paper presented the original data:

$$F = 0.73L^{2.94}.$$

To compare results, we fit a weighted exponential equation (BMDPAR, Dixon et al. 1988) to our data for

TABLE 3

Relationship between Total Fecundity (F_T) and Female Weight (W, without Ovary) for Oregon and California Sablefish, *Anoplopoma fimbria*, Females with No Histological Evidence of Past or Imminent Spawning

State	Oocyte diameter class (mm)	Linear equation $F_T = a + bW$: a	b	r^2	F	N	Estimate for for 2500 g female	Female weight (g): Mean	Range
California	0.78–1.16	−115,501	164.0	0.590	7.27	37	294,499	2,259	1,165–3,275
	0.78–1.30	−45,223	125.1	0.486	6.52	45	267,527	2,347	1,165–4,327
Oregon	0.74–1.17	−141,550	164.1	0.746	16.10	89	268,700	2,630	1,349–7,303
	0.74–1.38	−147,802	162.1	0.802	22.49	126	257,448	2,651	1,282–9,487
	1.18–1.38	−172,904	161.1	0.879	16.17	37	229,596	2,702	1,282–5,094
California + Oregon	0.74–1.17	−126,654	161.2	0.726	18.22	126	276,346	2,521	1,165–7,303

Females meeting specifications for potential annual fecundity estimation (average oocyte diameter between 0.71 and 1.17 mm) are compared to those that may have begun to spawn (average oocyte diameter larger than 1.17 mm).

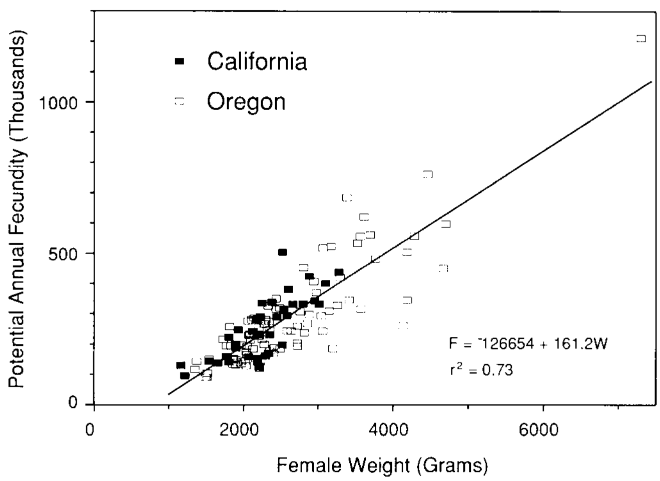

Figure 3. Potential annual fecundity as a function of body wet weight in grams (without ovary) for sablefish females taken off Oregon (November–December 1988) and off central California (October 1986).

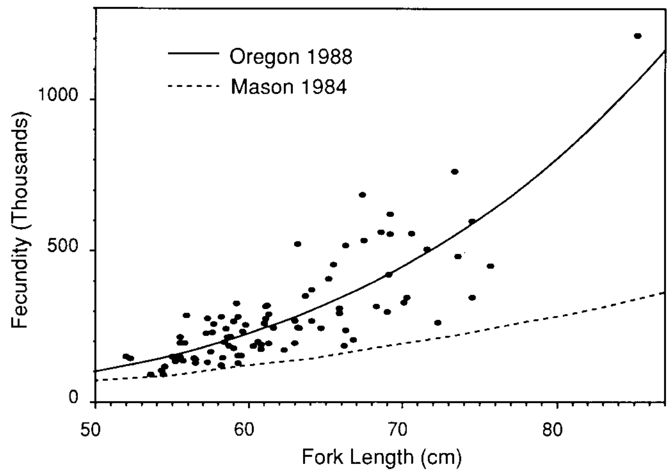

Figure 4. Potential annual fecundity of Oregon sablefish as a function of fork length (L) in cm (*solid circles* and *solid line*, $Y_F = 0.0033L^{4.4074}$) compared to Canadian females from Mason 1984 (*dashed line*, $F = 0.73L^{2.94}$).

potential annual fecundity from Oregon as a function of fork length, yielding the following relation:

$$Y_F = 0.0033L^{4.4074}$$

where L is fork length in cm and where the weights are the inverse of the variance of fecundity because the variance of the fecundity of females less than 63 cm was significantly smaller than the variance of fecundity for females ≥63 cm. The fecundity-length function for sablefish off Canada is distinctly lower than nearly all our Oregon data, regardless of the length of the female (figure 4).

After we selected females within the same length range (57–86 cm), an analysis of covariance applied to log-transformed data indicated that the two locations were significantly different for both of the intercepts ($F_{1, 112} = 5.78$, $P = 0.018$) and the slopes ($F_{1, 112} = 7.24$, $P = 0.008$). In fact, for a 67-cm female, the adjusted mean for potential fecundity from Oregon sablefish (358,613 oocytes) was about twice the Canadian sablefish fecundity estimate (171,099 oocytes). We believe the lower estimate of potential annual fecundity for the Canadian sablefish most likely results from loss of oocytes due to spawning. The Canadian sablefish females contained ovaries with large, advanced oocytes, which had peaks in distribution from 1.0 to 1.2 mm (Mason et al. 1983), indicating that some ovaries were probably above the upper bound of the maturity window. Additionally, the fish were taken off Canada during the spawning season, when up to 45% of female sablefish were spawning (Mason et al. 1983).

Evidence for Determinate Fecundity

Perhaps the most telling evidence for determinate annual fecundity is the decline in the standing stock of advanced oocytes during the spawning season. We combined Oregon data with central California data and examined the decline in the standing stock of advanced oocytes during the spawning season (figure 5). The standing stock of advanced oocytes in October–December (line for potential annual fecundity) is elevated above the line for females collected during the spawning season (January–March). Additional support for determinate annual fecundity in sablefish, but not unequivocal proof, is the existence of the hiatus in the oocyte distributions illustrated in Hunter et al. (1989) and Mason (1984), and the increase in the mean diameter of the advanced oocytes during the season for both California and Oregon sablefish (table 4).

A key issue affecting fishes with determinate annual fecundity is whether atretic losses during a season con-

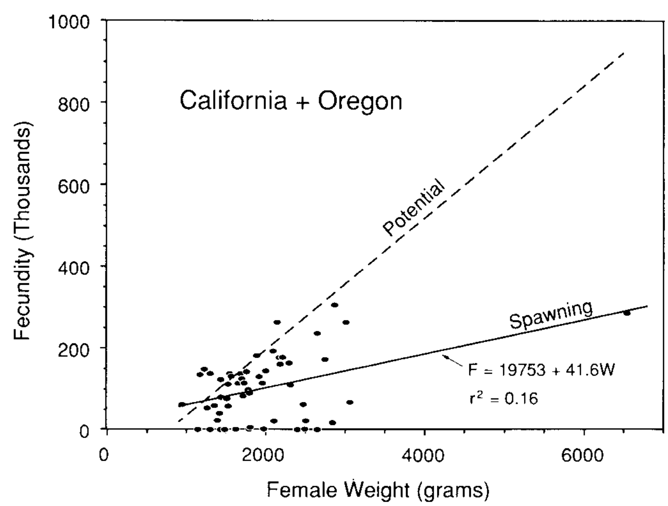

Figure 5. Total fecundity (number of advanced oocytes) as a function of weight (without ovary) for sablefish females collected off central California and Oregon during the spawning season (*solid circles* and *solid line*) compared to the potential annual fecundity (*dashed line*, $Y_F = -126{,}654 + 161.2W$) of California and Oregon females taken before spawning had begun.

TABLE 4
Mean Size and Standard Deviation of the Average Diameter of the Standing Stock of Advanced-Yolked Oocytes in Sablefish Used to Estimate Total Fecundity per Cruise

Cruise mean date and locality	Average diameter (mm) of advanced-yolked oocytes		Number of females
	Mean	S.D.	
October 25, 1986 California	1.00	0.17	51
December 6, 1988 Oregon	1.09	0.12	130
January 22, 1987 California	1.35	0.15	38
March 23, 1989 Oregon	1.32	0.23	6

stitute an important fraction of the potential annual fecundity. Although the fraction of α atretic oocytes varied between 0 and 0.72 when we used the whole-oocyte method (figure 6), the average fraction of advanced oocytes that were atretic was low (≤0.018) in both Oregon and California females (table 5). A stepwise multiple regression of female weight, elapsed time, and fraction of atretic oocytes on total fecundity indicated that the relation between fecundity and the proportion of atretic oocytes was not significant ($t = -1.88$, d.f. = 235, $P = 0.062$), but the coefficient for the fraction of oocytes atretic (−174,356) was negative, as would be expected. We conclude that atretic losses were not sufficiently high to produce a measurable decrement in total fecundity calculated from a regression model.

Histological methods revealed similar rates of α atresia of advanced-yolked oocytes in the ovaries of sablefish females in the two regions; α was detected histologically in the ovaries of 35% of the California females and in 30% of the Oregon females (table 5). Highly atretic ovaries—ones in which 50% or more of the advanced-yolked oocytes were undergoing alpha-stage atresia—were rare. None of the ovaries from California sablefish were highly atretic, and only 6.5% of those from Oregon were classed as such (table 5).

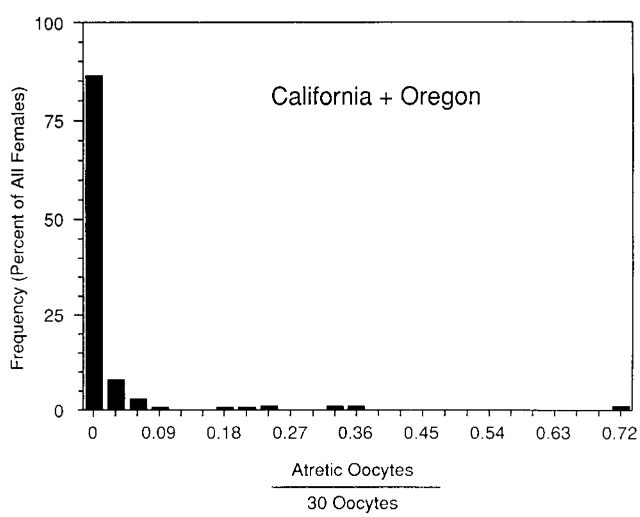

Figure 6. Percentage of sablefish (N = 236 females from California and Oregon) having various levels of atretic advanced-yolked oocytes (α stage), where the levels are the fraction of the 30 advanced-yolked oocytes that were atretic.

TABLE 5
Two Methods for Analyzing the Effect of Alpha-Stage Atresia of Advanced-Yolked Oocytes in Sablefish Collected off Central California and Oregon over the Spawning Season

Whole-Oocyte Method

State	Percent of females with atretic advanced-yolked oocytes	Mean percent of yolked oocytes affected per female: Mean	SD	Number females analyzed
California	12.8	1.2	4.5	94
Oregon	14.8	1.8	7.8	142

Histological Method

State	Percent of females with various percentages of advanced-yolked oocytes affected by atresia (α): None	0 < α < 50%	α ≥ 50%	Number females analyzed
California	65.0	35.0	0.0	43
Oregon	70.5	23.0	6.5	139

In summary, a variety of evidence indicates that atretic losses of potential fecundity were low in sablefish. The standing stock of atretic oocytes was low regardless of the method of assessment; the low temperature of adult sablefish habitat (3–7°C; Hunter et al. 1989) would prolong the duration of α atresia, and no significant relation existed between fecundity and atresia when the whole-oocyte method was used. This conclusion must be tempered with the knowledge that inferring a rate from knowledge of only the standing stock is inherently risky.

Alpha atresia of the advanced oocytes was detected in about twice as many females when we used the histological method rather than the whole-oocyte method. The histological method was more sensitive because it allowed us to detect more subtle changes in oocyte structure and because we scanned about 150 oocytes per ovary, compared to 30 oocytes in the whole-oocyte method. Despite the lack of sensitivity, the anatomical method was valuable because it made it easy to compare the standing stock of atretic and nonatretic oocytes and to infer losses due to atresia.

Batch Fecundity and Spawning Frequency

Samples of sablefish females in Oregon were taken either too early in the spawning season (November–December 1988) or too late (February–March 1989) to capture many females with hydrated oocytes. Only two

TABLE 6
Relative Fecundity (Number of Advanced-Yolked Oocytes per Gram Female Weight, without Ovary) of 19 Sablefish with Hydrated Oocytes Taken off Central California and Oregon

Potential spawnings ≥2			Potential spawnings = 1		
Not hydrated	Hydrated	Total	Not hydrated	Hydrated	Total
72	34	106	0.64	44	45*
55	28	83	0.64	25	26*
39	50	89	0.09	10.3	10*
37	35	72	0.07	43	43*
37	29	66	0.03	0.72	0.75*
12	36	48	0	16	16*
12	36	48*	0	22	22*
8	48	56	0	29	29*
5	39	44*	0	6.0	6*
4	35	39*			
Mean relative hydrated batch fecundity	37.1			21.8	
SD	7.3			15.2	

*Postovulatory follicles present from previous spawning(s).
Females were separated into two classes: those likely to spawn two or more batches because, in addition to the hydrated batch, substantial numbers of advanced oocytes existed in the ovary; and those in which the hydrated oocytes may have been the last spawning batch because, other than the hydrated batch, few or no advanced oocytes existed in the ovary.

of the Oregon females with hydrated oocytes were suitable for batch fecundity estimates. We added the data for these two fish to that provided by Hunter et al. (1989) for California sablefish females and recomputed the estimates of relative batch fecundity. The results were similar to those in the original report: the last spawning batch was about 22 hydrated oocytes per gram of female weight, whereas the previous spawning batches averaged 37 oocytes/g (table 6). A t test showed significant difference in the means ($P = 0.019$, $t = 2.76$, d.f. = 11). Using the revised data of relative batch fecundity and our current estimate of potential annual fecundity for a 2.5 kg female (276,346 oocytes, or 110 oocytes/g female weight), we calculated that, on the average, a 2.5 kg female sablefish would be expected to spawn 3.37 times per year (3 spawnings would equal 96 oocytes/g [37 + 37 + 22]).

Maturity of Females

Maturity of sablefish females from off Oregon's coast was estimated from fish taken early in the spawning season (November–December 1988), when anatomical classification yields a reasonably accurate assessment of maturity. The percentage of mature sablefish females ($P \times 100$) as a function of fork length was estimated with the following logistic regression equation (BMDPLR, Dixon et al. 1988):

$$P = \frac{e^{a+bx}}{1+e^{a+bx}}$$

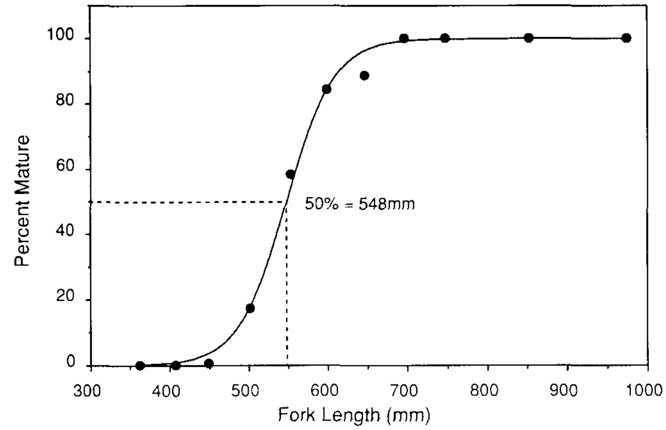

Figure 7. Percentage of mature sablefish (identified by active ovaries) within each 50 mm length class for females taken off Oregon in November–December 1988 (logistic curve parameters: $a = -18.072$; $b = 0.033$).

where x = fork length in mm; $a = -18.072$, SE(a) = 1.179, $t(a) = -15.32$; $b = 0.033$, SE(b) = 0.00214, $t(b) = 15.40$; and d.f. = 969; thus length at 50% mature was calculated as 548 mm FL with 95% CI of 546–592 mm (figure 7) for the sablefish taken off Oregon during November–December 1988. Our estimate of female length at 50% mature was about the same as the value of 55.3 cm estimated by Parks and Shaw (1987) for 569 female sablefish captured off Oregon and Washington early in the spawning season (August–September 1985).

We previously reported a value of 602 mm (Hunter et al. 1989) for sablefish taken off central California. The estimate was based on data from four or five observers using various multiple-stage anatomical criteria. By combining the stages differently, we obtained various values for the length at 50% mature ranging from 478 mm to 602 mm, depending on our interpretation of the criteria used to classify the ovaries (juvenile or early mature, spent or juvenile, immature or senescent). We believe a simple anatomical criterion (yolked oocytes visible) for maturity is preferable, with sampling being done just before the onset of the spawning season. These criteria were met by our estimate for Oregon sablefish, and thus we feel it is more reliable. The general issue of criteria for sexual maturity of females is discussed at length in Hunter et al. 1992.

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APPENDIX

TABLE A
Position, Date, Mean Bottom Depth, and Time of Trawl for Each Survey Period

		Latitude		Longitude					
Coll. no.	Haul no.	Deg.	Minute N	Deg.	Minute W	Month	Day	Depth (fath.)	Time (hrs)
November–December 1988									
1228	1	44	08.85	124	56.47	11	28	106	0044
1229	2	44	08.84	124	58.08	11	28	186	0555
1230	3	44	08.58	124	59.12	11	28	230	1006
1231	4	44	07.91	125	00.13	11	28	322	1417
1232	5	44	06.43	125	01.45	11	28	447	2118
1233	6	44	11.26	125	01.83	11	29	558	0232
1234	7	44	06.71	125	03.27	11	29	660	0829
1235	8	44	19.35	125	06.70	11	29	662	1910
1236	9	44	20.63	125	04.62	11	30	583	0310
1237	10	44	19.85	125	02.07	11	30	458	0904
1238	11	44	18.58	124	59.17	11	30	373	1315
1239	12	44	18.31	124	54.71	11	30	262	2053
1240	13	44	17.11	124	53.77	12	1	121	0112
1241	14	44	26.19	124	45.23	12	1	106	0801
1242	15	44	27.45	124	49.47	12	1	180	1249
1243	16	44	27.03	124	51.59	12	1	211	1720
1244	17	44	27.02	124	57.22	12	1	365	2043
1245	18	44	24.71	125	03.00	12	2	445	0454
1246	19	44	25.53	125	04.51	12	2	529	0938
1247	20	44	25.25	125	06.67	12	2	673	1437
1248	21	44	36.04	125	03.20	12	3	673	0135
1249	22	44	35.83	125	00.02	12	3	531	1057
1250	23	44	35.67	124	57.65	12	3	456	1511
1251	24	44	38.40	124	54.31	12	3	350	2053
1252	25	44	38.78	124	52.53	12	4	236	0344
1253	26	44	35.16	124	48.39	12	4	193	0743
1254	27	44	36.09	124	46.51	12	4	186	1357
1255	28	44	44.45	124	38.21	12	4	146	2027
1256	29	44	46.29	124	44.38	12	5	194	0036
1257	30	44	44.06	124	46.69	12	5	227	0349
1258	31	44	41.58	124	55.84	12	5	353	0844
1259	32	44	44.86	124	59.66	12	5	477	1556
1260	33	44	46.00	125	00.49	12	5	523	2037
1261	34	44	42.50	125	04.16	12	6	650	0131
1262	35	44	59.16	125	02.12	12	6	635	1244
1263	36	44	55.16	125	02.37	12	6	535	2118
1264	37	44	54.22	124	59.01	12	7	463	0302
1265	38	44	55.79	124	54.91	12	7	354	0829
1266	39	44	54.40	124	53.12	12	7	230	1517

continued on next page

TABLE A (continued)
Position, Date, Mean Bottom Depth, and Time of Trawl for Each Survey Period

		Latitude		Longitude					
Coll. no.	Haul no.	Deg.	Minute N	Deg.	Minute W	Month	Day	Depth (fath.)	Time (hrs)
1267	40	44	53.75	124	47.81	12	7	150	2123
1268	41	44	54.31	124	33.64	12	8	216	0054
1269	42	44	54.61	124	28.75	12	8	140	0629
1270	43	45	03.63	124	21.32	12	8	129	1354
1271	44	45	02.67	124	26.14	12	8	173	1812
1272	45	45	03.64	124	30.91	12	8	207	2245
1273	46	45	03.28	124	33.82	12	9	220	0345
1274	47	45	03.99	124	49.35	12	9	355	0909
1275	48	45	02.00	124	52.54	12	9	422	1534
1276	49	45	00.66	125	02.17	12	9	563	2138
1277	50	45	05.60	125	00.15	12	10	615	0326
1278	51	45	09.30	125	01.64	12	10	682	1649
1279	52	45	13.99	124	56.56	12	11	543	0221
1280	53	45	10.28	124	56.86	12	11	462	0720
1281	54	45	12.11	124	46.18	12	11	353	1303
1282	55	45	11.09	124	39.84	12	11	293	1935
1283	56	45	11.64	124	35.37	12	11	222	2301
1284	57	45	12.12	124	27.05	12	12	224	0211
1285	58	45	12.70	124	21.00	12	12	186	0600
1286	59	45	22.04	124	23.67	12	12	157	1221
1287	60	45	20.01	124	26.92	12	12	212	1805
1288	61	45	21.00	124	37.48	12	12	232	2244
1289	62	45	21.75	124	46.11	12	13	313	0233
February–March 1989									
1298	1	44	07.64	124	54.54	2	21	93	0845
1299	2	44	10.52	124	59.19	2	21	176	1919
1300	3	44	09.46	124	58.47	2	22	229	2021
1301	4	44	10.10	125	00.80	2	23	350	0322
WH*	5	44	07.38	125	03.47	2	23	660	1805
WH	6	44	20.02	125	08.57	2	26	670	1048
WH	7	44	23.09	125	06.86	2	26	589	1912
WH	8	44	19.25	124	47.95	2	26	85	2355
1302	9	44	21.03	124	48.26	2	27	106	1203
WH	10	44	22.37	124	51.28	2	27	279	2003
WH	11	44	22.46	124	51.43	2	27	277	2219
1303	12	44	22.67	124	51.44	2	28	273	0037
WH	13	44	18.61	124	59.29	2	28	364	0806
1304	14	44	17.84	124	59.23	2	28	367	1026
1305	15	44	23.48	124	47.12	3	1	111	0729
1306	16	44	27.26	124	48.63	3	1	176	1231
1307	17	44	27.28	124	51.09	3	1	207	1845
WH	18	44	27.30	124	56.00	3	2	360	0135
1308	19	44	54.62	124	28.88	3	8	142	1607
1309	20	44	54.41	124	32.83	3	9	199	0013
1310	21	44	53.61	124	46.89	3	9	144	0632
1311	22	44	52.31	124	52.32	3	10	240	1626
WH	23	44	56.40	124	59.80	3	22	515	0055
1312	24	44	56.73	124	59.78	3	22	514	0415
1313	25	45	04.18	124	59.19	3	22	610	1756
1314	26	44	58.94	125	01.21	3	23	567	0200
1315	27	45	05.87	124	55.51	3	23	430	1018
WH	28	45	02.60	124	50.03	3	23	348	1638
1316	29	45	02.62	124	49.99	3	23	350	1855
1317	30	45	01.66	124	30.87	3	24	217	0109
1318	31	45	11.88	124	35.63	3	24	217	0436
1319	32	45	09.71	124	39.66	3	24	292	1005
1320	33	45	12.51	124	46.33	3	24	351	1809
1321	34	45	15.44	124	51.27	3	25	462	0202
1322	35	45	11.24	124	57.86	3	25	535	0934
1323	36	45	24.71	124	55.20	3	25	600	2123
1324	37	45	23.33	124	52.02	3	26	473	0632
1325	38	45	23.64	124	24.28	3	31	152	0011
1326	39	45	21.81	124	26.12	3	31	209	0720
1327	40	45	19.85	124	36.32	3	31	234	1708
1328	41	45	12.62	124	20.87	3	31	182	2355

*No collection number was assigned to waterhauls (WH) containing no fish.

TABLE B
Total Weight, Mean Fork Length, and Number of Sablefish Randomly Selected from Trawl Catches for Various Survey Periods in Oregon Coastal Waters

November–December 1988

							Females							
			Males				Inactive				Active			
	All specimens				Length (mm)				Length (mm)				Length (mm)	
Coll. no.	N	Weight (lb)	N	Weight (lb)	Mean	SD	N	Weight (lb)	Mean	SD	N	Weight (lb)	Mean	SD
1228	0	0.0	0	0.0	—	—	0	0.0	—	—	0	0.0	—	—
1229	1	1.2	1	1.2	388	—	0	0.0	—	—	0	0.0	—	—
1230	32	77.3	15	25.6	419	39	14	25.5	434	42	3	26.2	685	61
1231	94	353.3	70	260.5	519	54	13	35.4	490	44	11	57.4	576	73
1232	97	413.5	73	283.7	550	35	3	13.9	588	31	21	115.9	604	57
1233	25	120.9	16	67.2	568	47	0	0.0	—	—	9	53.7	624	43
1234	39	212.7	18	88.4	576	44	1	3.2	521	—	20	121.1	613	56
1235	9	54.1	4	21.2	584	30	0	0.0	—	—	5	32.9	638	47
1236	40	199.9	18	76.8	564	35	5	24.7	593	50	17	98.4	616	36
1237	74	289.5	57	207.3	550	35	6	23.7	557	33	11	58.5	605	58
1238	100	349.8	66	218.7	520	39	22	62.1	504	38	12	69.0	584	53
1239	100	163.1	62	104.0	426	26	38	59.1	422	28	0	0.0	—	—
1240	33	47.9	17	24.7	413	30	16	23.2	416	31	0	0.0	—	—
1241	0	0.0	0	0.0	—	—	0	0.0	—	—	0	0.0	—	—
1242	20	51.3	8	15.0	439	33	11	31.2	495	74	1	5.1	593	—
1243	71	148.0	35	57.4	429	30	32	66.9	448	52	4	23.7	618	36
1244	100	317.8	67	214.7	513	47	25	64.0	496	42	8	39.1	582	36
1245	64	241.4	52	181.7	533	35	1	2.6	515	—	11	57.1	595	54
1246	71	271.6	46	156.8	528	29	6	18.8	521	22	19	96.0	585	49
1247	29	149.2	12	60.0	589	59	0	0.0	—	—	17	89.2	593	40
1248	41	185.8	20	79.8	549	37	1	2.9	528	—	20	103.1	586	34
1249	69	288.8	48	179.5	546	35	5	22.7	577	56	16	86.6	598	56
1250	100	256.0	77	143.5	541	28	6	22.4	555	6	17	90.1	595	58
1251	90	325.1	70	238.3	529	38	9	25.4	502	56	11	61.4	604	48
1252	25	59.3	10	18.3	438	44	14	31.1	462	48	1	9.9	716	—
1253	4	9.9	2	4.1	458	52	2	5.8	517	54	0	0.0	—	—
1254	7	32.7	1	2.3	474	—	3	7.0	484	57	3	23.4	652	71
1255	50	82.8	23	35.1	416	29	26	39.0	422	28	1	8.7	675	—
1256	4	28.0	0	0.0	—	—	2	3.0	412	6	2	25.0	746	149
1257	20	114.0	7	30.9	537	133	5	13.9	496	73	8	69.2	689	45
1258	100*	352.2	83	288.9	528	37	11	34.0	522	27	6	29.3	573	73
1259	68	264.0	48	171.9	542	39	4	13.8	542	68	16	78.3	590	59
1260	25	107.8	19	76.0	553	32	2	9.1	579	92	4	22.7	629	78
1261	59	290.4	32	124.6	553	46	3	14.3	584	35	24	151.5	628	60
1262	65	348.6	40	189.5	582	45	1	2.3	457	—	24	156.8	637	67
1263	21	80.0	18	66.5	544	30	0	0.0	—	—	3	13.5	573	25
1264	100	344.9	87	291.3	529	36	3	10.4	546	59	10	43.2	572	43
1265	78	270.9	60	197.5	524	43	12	32.7	496	50	6	40.7	639	63
1266	36	150.7	26	100.8	546	39	5	15.8	522	56	5	34.1	630	63
1267	10	23.7	5	7.6	419	20	4	8.5	459	70	1	7.6	632	—
1268	100	288.3	42	66.3	419	32	46	134.7	497	74	12	87.3	637	44
1269	1	1.6	1	1.6	427	—	0	0.0	—	—	0	0.0	—	—
1270	5	6.4	1	1.0	377	—	4	5.4	404	34	0	0.0	—	—
1271	7	13.4	5	7.5	413	14	2	5.9	506	112	0	0.0	—	—
1272	9	17.8	5	8.9	438	23	4	8.9	465	87	0	0.0	—	—
1273	24	52.6	10	16.0	422	30	13	31.1	475	62	1	5.5	592	—
1274	100	303.0	80	243.5	511	39	18	49.4	500	28	2	10.1	602	9
1275	100	333.7	89	281.9	519	28	0	0.0	—	—	11	51.8	581	61
1276	26	114.7	17	66.5	556	36	1	6.1	630	—	8	42.1	595	43
1277	21	98.6	12	48.1	560	47	2	8.8	570	44	7	41.7	620	34
1278	7	39.6	2	13.2	668	42	0	0.0	—	—	5	26.4	584	26
1279	100	394.3	70	264.2	541	40	2	6.7	540	14	28	123.4	568	55
1280	80	289.1	61	207.8	526	30	6	21.7	538	29	13	59.6	576	52
1281	88	300.4	65	220.2	530	40	16	46.3	509	36	7	33.9	576	44
1282	63	166.2	34	78.8	468	44	24	55.4	470	43	5	32.0	619	60
1283	11	19.2	8	13.2	433	26	3	6.0	456	10	0	0.0	—	—
1284	2	3.6	1	1.8	450	—	1	1.8	443	—	0	0.0	—	—
1285	8	23.9	3	6.1	452	32	5	17.8	525	93	0	0.0	—	—
1286	34	76.3	14	44.3	418	22	20	32.0	412	30	0	0.0	—	—

*In addition, a nonrandom active female of 974 mm and 25.6 lbs was sampled.

continued on next page

TABLE B (continued)
Total Weight, Mean Fork Length, and Number of Sablefish Randomly Selected from Trawl Catches for Various Survey Periods in Oregon Coastal Waters

							Females							
			Males				Inactive				Active			
	All specimens				Length (mm)				Length (mm)				Length (mm)	
Coll. no.	N	Weight (lb)	N	Weight (lb)	Mean	SD	N	Weight (lb)	Mean	SD	N	Weight (lb)	Mean	SD
November–December 1988														
1287	12	33.9	3	4.2	403	13	8	24.9	509	79	1	4.8	585	—
1288	27	91.8	11	28.3	489	37	11	29.1	486	64	5	34.4	640	48
1289	100	240.8	78	188.8	479	40	22	52.0	482	32	0	0.0	—	—
February–March 1989														
1298	5	3.1	4	2.5	315	7	1	0.6	323	—	0	—	—	—
1299	0	0.0	0	—	—	—	0	—	—	—	0	—	—	—
1300	12	17.6	7	9.2	409	29	5	8.4	441	25	0	—	—	—
1301	1	1.6	1	1.6	443	—	0	—	—	—	0	—	—	—
1302	8	4.8	3	1.7	315	—	5	3.1	320	16	0	—	—	—
1303	100	144.1	50	67.7	405	21	50	76.4	416	34	0	—	—	—
1304	0	0.0	0	—	—	—	0	—	—	—	0	—	—	—
1305	17	10.3	9	5.0	314	12	8	5.3	323	42	0	—	—	—
1306	100	134.0	47	58.2	397	28	53	75.8	406	26	0	—	—	—
1307	51	73.6	21	29.7	416	24	30	43.9	420	25	0	—	—	—
1308	7	7.1	4	3.6	345	55	3	3.5	397	8	0	—	—	—
1309	5	14.8	2	3.7	449	11	3	11.1	519	167	0	—	—	—
1310	98	152.9	41	59.3	416	19	57	93.6	433	31	0	—	—	—
1311	4	9.9	2	4.6	487	7	2	5.3	505	4	0	—	—	—
1312	69	242.8	44	136.7	524	30	24	100.7	575	46	1	5.4	597	—
1313	27	114.3	23	96.2	574	40	3	12.7	579	27	1	5.4	633	—
1314	50	186.6	45	151.7	542	36	5	34.9	670	57	0	—	—	—
1315	64	197.6	56	167.5	517	32	8	30.1	550	66	0	—	—	—
1316	15	56.5	11	37.8	536	50	4	18.7	563	31	0	—	—	—
1317	3	9.5	1	1.9	455	—	2	7.6	558	36	0	—	—	—
1318	2	3.4	2	3.4	438	5	0	—	—	—	0	—	—	—
1319	27	95.8	10	31.4	518	64	17	64.4	545	91	0	—	—	—
1320	15	53.0	11	38.8	538	74	4	14.2	550	29	0	—	—	—
1321	14	56.5	6	23.4	550	36	8	33.1	575	38	0	—	—	—
1322	45	149.5	38	115.0	524	29	7	34.5	584	59	0	—	—	—
1323	100†	324.7	93	293.1	527	29	6	26.9	588	33	1	4.7	531	—
1324	58	167.1	53	150.1	513	28	5	17.0	537	28	0	—	—	—
1325	6	5.6	3	2.9	379	50	3	2.7	363	37	0	—	—	—
1326	3	4.3	3	4.3	420	39	0	—	—	—	0	—	—	—
1327	12	40.6	4	14.7	545	8	8	25.9	522	69	0	—	—	—
1328	2	3.0	1	1.5	423	—	1	1.5	420	—	0	—	—	—

†More than 100 sampled; only first 100 used for analyses.

TABLE C
Standing Stock of Oocytes in Sablefish Ovaries in Order of Female Weight (without Ovary) within a Survey Period

November–December 1988

Coll. no.	Fish no.	Wet weight (g)	Fork length (mm)	Ovary weight (g)	Standing stock of advanced oocytes	Advanced oocyte diameter (mm) Mean	SD
1280	204	1281.76	487	92.24	57422	1.21	0.038
1279	204	1323.53	512	57.47	49471	1.18	0.048
1260	204	1349.37	545	87.63	117804	0.97	0.048
1237	205	1371.28	523	91.72	144697	1.00	0.073
1263	216	1468.54	545	155.46	145643	1.21	0.041
1251	201	1489.89	544	59.11	92182	0.95	0.031
1266	201	1511.53	536	68.47	92065	1.04	0.064
1233	202	1513.58	547	155.42	129306	1.28	0.056
1264	219	1517.28	543	114.72	105521	1.10	0.063
1231	202	1541.83	520	80.17	151302	0.84	0.055
1258	241	1591.68	521	141.32	130273	1.22	0.034
1232	207	1595.43	539	132.57	106757	1.26	0.049
1261	201	1703.67	560	144.33	142350	1.24	0.059
1244	252	1725.52	555	173.48	216567	1.09	0.040
1280	220	1745.19	550	122.81	109741	1.18	0.045
1258	252	1751.94	565	173.06	161527	1.19	0.039
1265	222	1762.75	554	187.25	153742	1.25	0.043
1248	206	1768.08	555	122.92	196335	0.96	0.053
1288	213	1806.32	577	111.68	258684	0.92	0.069
1281	239	1825.92	558	189.08	195681	1.12	0.050
1264	218	1846.90	550	148.10	150581	1.12	0.035
1278	203	1852.65	552	124.35	135561	1.07	0.034
1274	204	1858.71	595	151.29	153408	1.16	0.048
1248	202	1886.68	573	63.32	132565	0.89	0.069
1244	223	1890.82	588	185.18	181299	1.18	0.057
1277	209	1894.19	555	130.81	149456	1.09	0.048
1279	208	1905.16	565	165.84	142007	1.17	0.032
1245	203	1906.26	570	133.74	130913	1.21	0.051
1280	205	1959.11	567	153.89	142173	1.19	0.034
1276	201	1963.82	584	192.18	198220	1.13	0.052
1259	202	1964.25	557	112.75	136680	0.97	0.140
1250	206	1995.50	576	211.50	172573	1.24	0.044
1263	218	2017.33	580	181.67	159706	1.26	0.033
1279	202	2022.19	583	130.81	147292	1.06	0.051
1250	204	2029.13	608	198.87	174518	1.16	0.051
1234	203	2029.58	565	160.42	130089	1.10	0.039
1275	218	2042.14	613	124.86	194514	1.04	0.040
1262	202	2042.19	575	116.81	166726	0.98	0.053
1282	225	2057.95	573	135.05	277740	0.92	0.107
1235	204	2068.24	576	198.76	230776	1.10	0.042
1245	202	2081.06	596	148.94	233221	1.01	0.060
1263	210	2085.23	594	218.77	157134	1.31	0.049
1264	207	2089.65	586	179.35	215439	1.04	0.041
1281	253	2098.97	593	218.03	281991	1.03	0.055
1244	235	2099.10	598	186.90	164364	1.20	0.042
1236	201	2106.61	584	163.39	143125	1.21	0.054
1246	204	2119.68	587	192.32	186391	1.11	0.040
1287	205	2120.01	585	71.99	243002	0.74	0.053
1238	210	2133.29	559	101.71	287712	0.82	0.051
1276	202	2157.18	562	189.82	146655	1.31	0.041
1275	217	2162.02	593	162.98	153656	1.12	0.045
1247	204	2201.51	598	207.49	255574	1.02	0.046
1242	209	2206.81	593	131.19	128330	0.95	0.040
1243	201	2211.62	572	74.38	227696	0.81	0.060
1278	206	2212.66	582	130.34	122464	1.17	0.049
1238	204	2223.98	564	138.02	146224	1.09	0.034
1259	207	2245.32	588	147.68	216796	1.07	0.051
1234	204	2271.62	590	202.38	266856	1.12	0.048
1261	203	2275.66	606	182.34	200147	1.09	0.039
1235	202	2280.98	641	226.02	268166	1.07	0.049
1258	208	2288.17	582	191.83	281858	1.04	0.042
1273	224	2323.67	592	186.33	326963	0.94	0.046
1288	206	2335.00	611	106.00	275506	0.88	0.070

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TABLE C (continued)
Standing Stock of Oocytes in Sablefish Ovaries in Order of Female Weight (without Ovary) within a Survey Period

November–December 1988

Coll. no.	Fish no.	Wet weight (g)	Fork length (mm)	Ovary weight (g)	Standing stock of advanced oocytes	Advanced oocyte diameter (mm) Mean	SD
1278	201	2346.13	590	214.87	178505	1.12	0.034
1276	203	2346.21	632	163.79	248286	1.01	0.047
1236	204	2373.81	593	180.19	173997	1.18	0.055
1277	201	2392.96	611	289.04	236958	1.20	0.035
1274	278	2401.78	608	192.22	189929	1.17	0.039
1230	232	2402.10	623	76.90	172461	0.81	0.078
1266	217	2428.17	611	141.83	316590	0.84	0.058
1268	227	2432.21	637	175.79	350705	0.97	0.054
1243	208	2460.65	613	145.35	291572	0.97	0.061
1254	206	2477.19	612	239.81	320185	1.10	0.043
1232	204	2485.08	603	194.92	185176	1.15	0.039
1247	202	2572.86	630	254.14	173382	1.29	0.043
1248	201	2575.78	616	209.22	245790	1.05	0.040
1237	210	2637.80	633	244.20	243895	1.12	0.034
1237	208	2712.98	637	263.02	258215	1.21	0.042
1249	205	2716.93	668	228.07	205498	1.15	0.048
1250	205	2717.68	640	166.32	150693	1.20	0.065
1254	202	2717.94	610	180.06	260752	1.01	0.029
1246	216	2718.75	630	170.25	194841	1.06	0.072
1265	207	2757.15	659	184.85	309520	0.93	0.067
1288	205	2802.49	655	313.51	454950	1.03	0.057
1259	201	2813.62	663	183.38	238025	1.03	0.056
1268	219	2856.00	630	225.00	268702	1.07	0.035
1260	201	2877.27	690	236.73	298836	1.01	0.048
1251	205	2940.82	652	216.18	407804	0.89	0.075
1256	201	2971.33	641	133.67	371095	0.82	0.068
1277	202	3000.63	658	274.37	177216	1.38	0.035
1233	206	3026.84	669	277.16	283363	1.18	0.033
1243	218	3044.41	659	100.59	294290	0.82	0.080
1233	203	3057.59	647	237.41	243932	1.14	0.098
1238	206	3062.41	663	319.59	518580	1.12	0.039
1262	210	3148.31	659	243.69	310222	1.02	0.046
1249	217	3164.58	647	360.42	391366	1.19	0.043
1267	210	3172.94	632	291.06	523498	1.00	0.056
1231	213	3197.41	662	104.59	185875	0.96	0.044
1247	205	3227.66	647	297.34	256887	1.25	0.047
1282	205	3250.71	678	277.29	247440	1.21	0.040
1260	215	3256.73	701	265.27	328736	1.07	0.044
1231	205	3292.98	691	275.02	421292	1.03	0.052
1275	220	3355.37	673	236.63	229323	1.20	0.049
1282	213	3382.20	674	414.80	686743	1.00	0.082
1265	208	3394.10	701	558.90	492978	1.19	0.043
1245	201	3410.57	703	315.43	346096	1.13	0.089
1255	207	3525.60	675	429.40	534972	1.08	0.038
1251	209	3558.50	692	516.50	557040	1.14	0.057
1235	203	3567.94	683	307.06	316702	1.12	0.047
1257	204	3610.60	692	585.40	622620	1.13	0.061
1266	206	3621.30	683	558.70	552828	1.21	0.043
1230	203	3690.50	686	530.50	563099	1.17	0.042
1257	203	3760.59	736	359.41	482601	1.11	0.057
1257	220	3963.00	722	547.00	552886	1.19	0.047
1249	206	4131.28	723	233.72	262975	1.08	0.043
1234	201	4159.47	717	223.53	174829	1.21	0.044
1252	213	4176.93	716	313.07	506350	0.99	0.043
1261	204	4185.30	745	330.70	346537	1.14	0.062
1268	231	4275.81	706	303.19	559389	0.99	0.079
1254	203	4456.20	734	537.80	764413	1.00	0.089
1257	205	4507.70	755	710.30	686548	1.23	0.064
1232	206	4667.40	757	405.60	451441	1.09	0.148
1230	208	4693.80	745	517.20	599378	1.05	0.068
1250	220	5093.80	774	598.20	647755	1.18	0.122
1256	204	7303.40	852	947.60	1213591	1.03	0.059
1258	301	9486.60	974	1676.40	1438854	1.28	0.053

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TABLE C (continued)
Standing Stock of Oocytes in Sablefish Ovaries in Order of Collection Number within the Survey Period

February–March 1989

Coll. no.	Fish no.	Wet weight (g)	Fork length (mm)	Ovary weight (g)	Standing stock oocytes Yolked	Hydrated	Total	Advanced oocyte diameter (mm) Mean	SD
1312	214	2169.27	597	262.730	177724	0.0	177724	1.33	0.040
1312	225*	1794.70	581	50.302	0	1230.7	1231	0.00	0.000
1312	240	2491.29	662	55.709	81	1792.7	1874	0.00	0.000
1313	225*	2396.34	633	53.655	352	286.5	638	1.23	0.044
1313	226*	1977.61	587	43.391	151	1295.6	1446	1.24	0.047
1315	214*	1436.52	532	23.485	0	173.8	174	0.00	0.000
1315	225*	1146.24	487	31.759	0	240.2	240	0.00	0.000
1315	226*	1622.54	532	16.460	296	573.6	870	0.99	0.082
1321	201*	2645.97	640	48.035	24	23.7	47	0.00	0.000
1321	203*	1301.38	532	21.618	0	63.8	64	0.00	0.000
1321	214*	1483.67	549	31.334	553	46.7	599	1.67	0.210
1323	270	1683.80	531	439.200	92657	46400.2	139057	1.45	0.041

*These females with ovaries containing hydrated oocytes were not used for batch fecundity analyses because the ovaries showed histological evidence of new postovulatory follicles, which indicated that some hydrated oocytes had been lost to spawning.