On the Fecundity of the Sablefish *(Anoplopoma fimbria)* in Canadian Waters

J. C. Mason

Department of Fisheries and Oceans
Fisheries Research Branch
Pacific Biological Station
Nanaimo, British Columbia V9R 5K6

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ABSTRACT

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The ovaries of 55 mature, female sablefish (57-110 cm FL) captured in Canadian waters in early February, 1981 were subjected to a fecundity analysis. The ovaries contained a bimodal frequency distribution of oocyte diameters with peaks at 100 µm and between 1000 and 1200 µm. Fecundity was defined as the number of yolked, advanced oocytes 500 µm in the ripe ovary. Fecundity was expressed by the equation F = 0.73FL 2.94 with a correlation coefficient (r) of 0.79. Fecundity of individual females ranged from 58,200 to 977,000 advanced eggs, and is somewhat lower than values reported in the literature. Fecundity was related to length of female but not to age in years. Relative fecundity (advanced eggs/g) declined with female length and there was a wide range of fork length within females of comparable age, as aged by otolith reading. The largest, ripening 5 yr old female (69.5 cm FL) was more than 5 cm longer than many older females in the sample.

RESUME

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Les ovaires de 55 morues charbonnières matures (57-110 mm L.F.), capturées au début de février 1981 dans les eaux canadiennes, ont été soumis à une analyse de fécondité. Une distribution bimodale des fréquences de diamètres des oocytes possédait des sommets à 100 µm et entre 1000 et 1200 µm. On définit la fécondité comme le nombre d'oocytes avancés contenant du vitellus et mesurant plus de 500 µm dans l'ovaire mature. Elle est exprimée par l'équation F = 0.73 L.F. 2.94, dont le coefficient de corrélation (r) s'élève à 0.79. La fécondité des femelles variait de 58,200 à 997,000 oeufs avancés, valeurs quelque peu inférieures à celles que donnent des ouvrages à ce sujet. La fécondité était reliée à la longueur du poisson mais non à l'âge. La fécondité relatif (oeufs avancés/g) baissait en fonction de la longueur de la femelle. La longueur à la fourche variait beaucoup chez des femelles ayant le même âge selon les lectures d'otolithes. La plus grosse femelle en maturation, âgée de 5 ans (69.5 cm L.F.) mesurait au-delà de 5 cm de plus que beaucoup des femelle plus vieille de l'échantillon.

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INTRODUCTION

A Canadian fishery for sablefish has been prosecuted since the late nineteenth century (Ketchen and Forrester 1954). In the past 5-6 years the Canadian fishery has undergone rapid development, is deployed along the entire outer Continental Shelf of British Columbia, and currently has the highest landed value in the groundfish fisheries of the Canadian Pacific coast, including that for Pacific halibut (*Hippoglossus stenolepis*) (Mason et al. 1983).

A fecundity analysis was undertaken, in conjunction with parallel researches on the seasonal timing of reproduction and location of spawning grounds based on ichthyoplankton surveys (Mason et al. 1983). The latter report included some major findings on fecundity but excluded other information, including sampling and statistical data, that should prove useful to further studies on fecundity germane to managing the stock.

METHODS AND MATERIALS

Ovaries of 220 females 58-110 cm FL were collected at sea from commercial catches made during the first week of February 1981. Catches were made in Korean-type bottom traps fished off the northwest coast of Vancouver Island in major statistical areas 3D and 5A, including areas seaward of Quatsino Sound and Triangle Island, and in area 5E off the Queen Charlotte Islands. Traps were fished at depths ranging between 275 and 425 fathoms.

Fork length, maturity state (after Foucher and Beamish 1977), were noted. Otoliths were extracted (sagittae) and stored in compartmentalized plastic trays filled with glycerin and water (1:1), to which a little thymol was added to retard biological activity. The otoliths were read in the Ageing Unit at PBS, Nanaimo using the "break and burn" method (Chilton and Beamish 1982).

Although ovaries of 220 females were collected, failure to preserve the ovaries adequately in 10% formaldehyde led to the loss of many ovaries, particularly those from larger females. However, the ovaries of 55 mature females were selected so that no more than three ovaries fell within any centimeter interval of fork length.

In the laboratory, the 55 formaldehyde-preserved ovaries were transferred to Gilson's fluid, as modified by Simpson (1951), for nearly four months. This period allowed sufficient time for breakdown of ovarian connective tissue prior to extracting the eggs. Ovaries were washed thoroughly in cold running fresh-water over a stacked series of stainless steel meshed screens (60-1440 μm) and gently broken apart by hand and small bristle brush to separate the hardened eggs from the remaining ovarian connective tissue. The cleaned eggs caught on the various screens were then recombined and stored in 5% formaldehyde solution.

Eggs from a single ovary were transferred to a 20 L glass reservoir filled to either 10 or 15 L. The contents of the reservoir were then stirred vigorously with a flat, wooden paddle, using a revolving figure-eight pattern of stirring. In concert with the stirring activities, a second person extracted 1-2 mL volumetric subsamples, using a Stempel pipette, from one quadrant within the reservoir. Fifty subsamples were so transferred to individual Petri dishes.

Under the dissecting microscope, at 50X magnification, all eggs from five subsamples were sized and counted in 20 μm diameter intervals over diameter range from 40 to 1400 μm. These results were then used to construct a size-frequency histogram describing the ovary. Eggs larger than 500 μm diameter were counted in the remaining 45 subsamples to provide 50 volumetric counts of large (advanced) eggs.

The 50 counts were marshalled into 5 groups of 10 counts each, reflecting progressive processing and counting, and the group means were further averaged and provided grand mean and standard error values.

RESULTS AND DISCUSSION

No difficulty was encountered in distinguishing between ripening, well-yolked eggs (advanced) and smaller eggs containing scant or no yolk material. Without exception, all ovaries examined contained a bimodal distribution of egg size with peaks occurring at 100 μm and between 1000 and 1200 μm (Figs. 1-4). The two size classes of eggs were separated by a consistent gap between 300 and 800 μm of some 500 μm egg diameter. Figures 1-4 indicate also that the size relations in the diameter distributions were not affected by size of female. Most eggs in the ovaries were immature and contained little or no yolk material.

The estimated fecundities (number of advanced eggs), various sampling statistics, and 95% confidence limits of the estimates are given in Table 1, and plotted against fork length (FL) in Fig. 5. These plots are best described by a power curve ($Y=aX^b$) up to and including 90 cm FL, giving the following fecundity equation:

$$F = 0.73FL^{2.94}$$

where the correlation coefficient (r) for the regression was 0.79.

Log-based and exponential curves did not fit the data satisfactorily, as indicated by low "r" values. Linear regression produced a correlation coefficient (r) of 0.81 but; the resulting curve strayed from the data plots at the high and low ends of the FL range, making it doubtfully appropriate for females of larger FL.

The smallest and largest females (57.9 and 110.2 cm FL) gave minimum and maximum fecundity estimates of 58 200±931 and 977 000±16 400 advanced eggs in the ovaries. The average-sized female in the commercial fishery is 70 cm FL (R. J. Beamish unpublished data) and thus produces some 194,000 advanced eggs during the annual spawning season.

Fecundities reported in the literature are higher than those reported here, both to the north and south of Canadian Pacific waters (Mason et al. 1983). Unfortunately, the potential usefulness of comparing our results with those reported in the literature is sharply curtailed by a general lack of adequate description of procedural and statistical methodology associated with the estimates reported previously. Hence, this report endeavors to provide opportunity for procedural replication leading to more acceptable scientific comparisons.

The fecundity of Canadian sablefish is primarily associated with size (FL) not age. The size range within age groups is extremely broad, even in this rather small sample of female fish. The youngest and oldest females in the sample were 5 and 43 years of age by otolith reading (Table 1), the largest 5-yr old (69.5 cm FL) being larger (¨5 cm FL) than many females older than 15 yrs. The range of FL found within age groups, range of estimated fecundity, and range of relative fecundity (no. advanced eggs/g) are compiled in Table 2. Note that 10 of 13 age groups (5 to 18 years) had larger individual fish, consequently higher fecundity ceilings) than many older fish from 20 to 43 years of age in the sample.

Although the sample size is small, 10 of 14 pairs of low-high ranges in estimated fecundity within age groups indicate that the largest fish in the age group has a lower relative fecundity than does its smaller counterpart. A lowering of relative fecundity with increased fork length is also evident from the relative fecundity values in 5 cm length groups calculated from the fecundity equation and the length-weight equation:

$$W_{(g)} = 1.4 \times 10^{-6} \; FL_{(cm)}^{3.5025}$$

provided by Beamish et al. (1980) given in Table 3. Relative fecundity declines from a high of 56.6 eggs/g for a female 55 cm FL to at least 40.5 eggs/g at 90 cm FL. If valid, such a relationship indicates that the relative potential reproductive contribution of individual females decreases with increased size.

As in many stocks of marine fishes, sablefish stocks occasionally produce relatively large age classes which may dominate the stock for many years subsequent to their recruitment. The potential effects on reproductive power of the stock wrought by reduction in relative fecundity with increased individual size could be exaggerated in stocks subject to large-scale fluctuations in recruitment strength, particularly if relative fecundity is linked to age-specific growth rate and if growth rate is reduced in large age classes. Future studies on sablefish should pay attention to assessment of the potential constraints on the reproductive power of the stock of changes in relative fecundity, and age-growth-fecundity linkages relative to environmental constraints operating during the pre-recruitment stages of the life history.

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Table 1. Fork length, estimated age, estimated fecundity, and related statistics for 55 female sablefish taken from Canadian waters, 1981. Estimated fecundity derived from 50 volumetric subsamples/ovary.

ID no.		FL (cm)	Est. age (yrs)	Subsample volume (ml)	Egg count $G_{\bar{X}}$	SE	$\frac{2SE}{G_{\bar{X}}}$ X100	Est. fec. ± 2 SE
81	16487	57.9	22	2	11.64	0.46	7.9	58,200± 4600
29	16435	58.0	5	2	38.36	0.51	2.7	191,800± 5100
30	16436	58.0	6	2	22.94	0.38	3.3	114,700± 3800
112	16518	58.9	15	2	56.78	0.64	2.3	283,900± 6400
80	16486	60.0	-	2	27.38	0.93	6.8	136,900± 9300
22	16427	60.7	5	2	22.74	0.33	2.0	113,700± 2300
79	16485	61.0	~ 28	2	12.90	0.17	2.6	64,500± 1700
191	16596	61.4	7	2	32.48	0.26	1.3	162,400± 2071
28	16434	62.0	7	2	25.58	0.66	5.2	127,900± 6600
13	16419	75.6	15	1	25.02	0.18	1.4	250,200± 3600
219	16624	63.3	6	2	41.14	0.62	3.0	205,700± 6400
194	16599	64.0	11	2	32.36	0.37	2.3	161,800± 3700
122	16528	64.2	6	2	26.16	0.19	1.5	130,800± 1900
202	16607	65.0	26	2	20.26	0.26	2.6	101,300± 2600
166	16571	65.0	8	2	39.04	0.93	4.8	195,200± 9300
41	16447	66.1	15	2	22.40	0.25	2.2	112,000± 2500
187	16592	66.5	11	2	37.14	0.58	3.1	85,700± 2677
1	16406	67.1	12	2	23.90	0.62	5.2	119,500± 6200
94	16500	67.3	18	1	24.52	0.15	1.2	245,200± 3000
143	16549	67.5	7	2	25.46	0.27	2.1	127,300± 2700
36	16442	67.8	17	1	23.96	0.45	3.8	239,600± 9000
10	16415	69.2	12	2	52.14	0.80	3.1	260,700± 8000
128	16534	69.5	5	2	37.78	0.66	3.5	188,900± 6600
92	16498	70.0	14	1	24.04	0.33	2.7	240,400± 6600
126	16532	71.1	20	2	37.20	0.97	5.2	186,000± 9700
48	16454	72.0	8	2	44.62	0.71	3.2	223,100± 7100
59	16465	73.0	20	2	47.60	0.91	3.8	238,000± 9100
68	16474	74.0	13	2	52.60	1.10	4.2	263,000± 1100
121	16527	74.9	~ 15	2	33.00	0.88	5.3	165,000± 8800
3	16408	75.4	11	2	45.70	0.89	3.9	228,500± 8912
155	16561	76.2	21	2	40.72	0.25	1.2	203,600± 2500
55	16461	76.8	12	2	33.74	1.02	6.1	168,700±10200
17	16426	62.8	6	2	51.56	0.61	2.4	257,800± 6100
223	16628	78.0	~ 17	2	53.70	0.58	2.2	268,500± 5800
146	16552	78.0	16	2	30.86	0.36	2.3	154,300± 3600
75	16481	80.2	15	2	40.48	1.05	5.2	202,400±10500
117	16523	80.4	22	1	30.89	0.99	6.4	308,900±19800
176	16581	80.5	23	2	38.28	0.67	3.5	191,400± 6700
171	16576	81.0	8	1	34.24	0.67	3.9	342,400±13400
105	16511	81.1	11	2	40.78	0.60	2.9	203,900± 6000
210	16615	81.3	21	2	45.68	1.09	4.8	228,400±10900
103	16509	81.5	13	1	27.80	0.45	3.2	278,000- 9000
142	16548	81.5	13	1	33.62	0.31	1.8	336,200± 6200
211	16616	82.5	~ 43	2	43.74	1.00	4.6	218,700±10000

Table 1 (cont'd)

ID no.		FL (cm)	Est. age (yrs)	Subsample volume (ml)	Egg count $G_{\bar{x}}$	SE	$\frac{2SE}{G_{\bar{x}}}$ X100	Est. fec. ± 2 SE
124	16530	82.9	14	1	48.50	0.64	2.6	485,000±12800
159	16565	84.4	11	1	34.16	0.22	1.3	341,600± 4441
65	16471	84.5	~18	1	31.38	0.28	1.8	313,800± 5600
26	16431	85.5	32	2	83.40	0.83	2.0	416,700± 8300
57	16463	85.6	15	1	42.90	0.48	2.2	429,000± 9600
213	16618	85.7	11	1	46.22	1.40	4.8	462,200±22000
107	16513	87.4	9	1	48.62	0.37	1.5	486,200± 7400
110	16516	88.5	15	2	48.12	0.69	2.9	240,600± 6900
60	16466	89.2	21	1	52.44	0.53	2.0	524,400±10600
46	16452	94.5	20	1	56.36	0.79	2.8	563,600±15800
53	16459	110.2	34	1	97.70	0.82	1.7	977,000±16400

Table 2. Data from Table 1 assembled by age group, giving ranges for fork length, fecundity (advanced oocytes), and relative fecundity (advanced oocytes/g).

No. of fish	Est. age	FL range (cm)	Fecundity range	Relative Fecundity range
3	5	58.0-69.5	113,700-191,800	46.2-91.3
4	6	58.0-64.2	114,700-257,800	43.6-72.2
3	7	61.4-67.5	127,300-162,400	35.7-63.2
3	8	65.0-81.0	195,200-343,400	49.8-62.4
1	9	87.4	486,200	55.0
6	11	64.0-85.7	85,700-462,200	30.0-56.0
3	12	67.1-76.8	119,500-260,700	30.0-66.8
3	13	74.0-81.5	263,000-336,200	40.2-53.3
2	14	70.0-82.9	240,400-485,000	59.2-66.1
7	15	58.9-88.5	112,000-429,000	26.1-127.9
1	16	78.0	154,300	26.0
2	17	67.8-78.0	239,600-268,500	45.3-66.0
2	18	67.3-84.5	245,200-313,800	40.0-69.3
3	20	71.1-94.5	186,000-563,600	43.4-50.6
3	21	76.2-89.2	203,600-524,400	33.3-55.3
2	22	57.9-80.4	58,200-308,900	27.8-46.8
1	23	80.5	191,400	28.9
1	26	65.0	101,300	32.4
1	~ 28	61.0	64,500	25.7
1	32	85.5	416,700	50.9
1	34	110.2	977,000	49.1
1	~ 43	82.5	218,700	30.3

Table 3. Estimated weights, fecundities, and relative fecundities for sablefish in Canadian waters, in 5 cm length intervals, from regression equations.

Fork length (cm)	Weight (g)	Fecundity (advanced eggs)	Relative fecundity (eggs/g)
55	1745	98,671	56.5
60	2367	126,160	53.3
65	3132	158,162	50.5
70	4061	194,987	48.0
75	5171	236,937	45.8
80	6482	284,314	43.9
85	8015	337,413	42.1
90	9792	396,527	40.5
95	11833	461,948	39.0
100	14162	533,962	37.7
105	16801	612,855	36.5
110	19775	698,908	35.3

FIGURES

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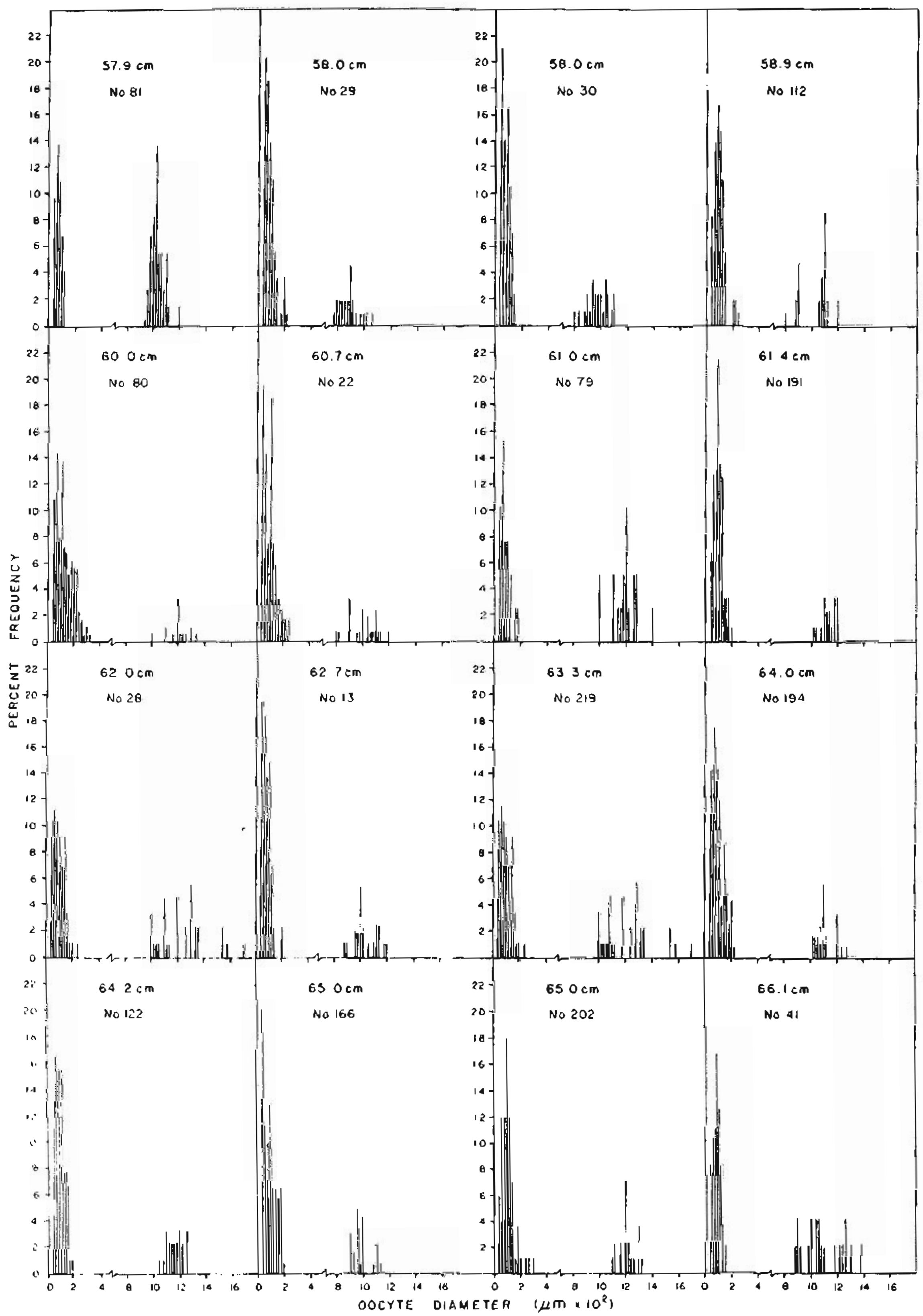

Fig. 1. Frequency distributions of oocyte diameters from ripe ovaries of sablefish 58-66 cm FL.

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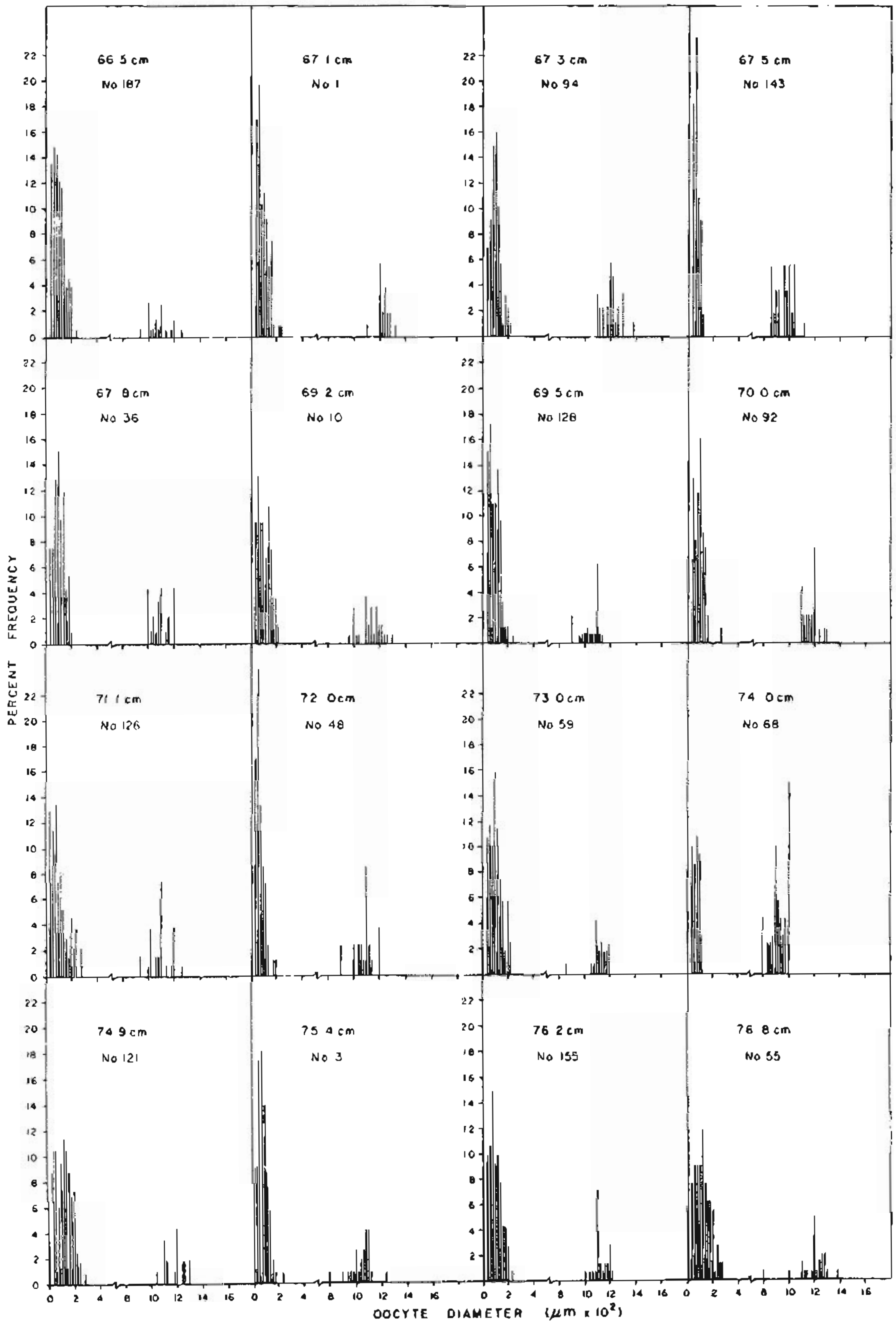

Fig. 2. Frequency distributions of oocyte diameters from ripe ovaries of sablefish 67-77 cm FL.

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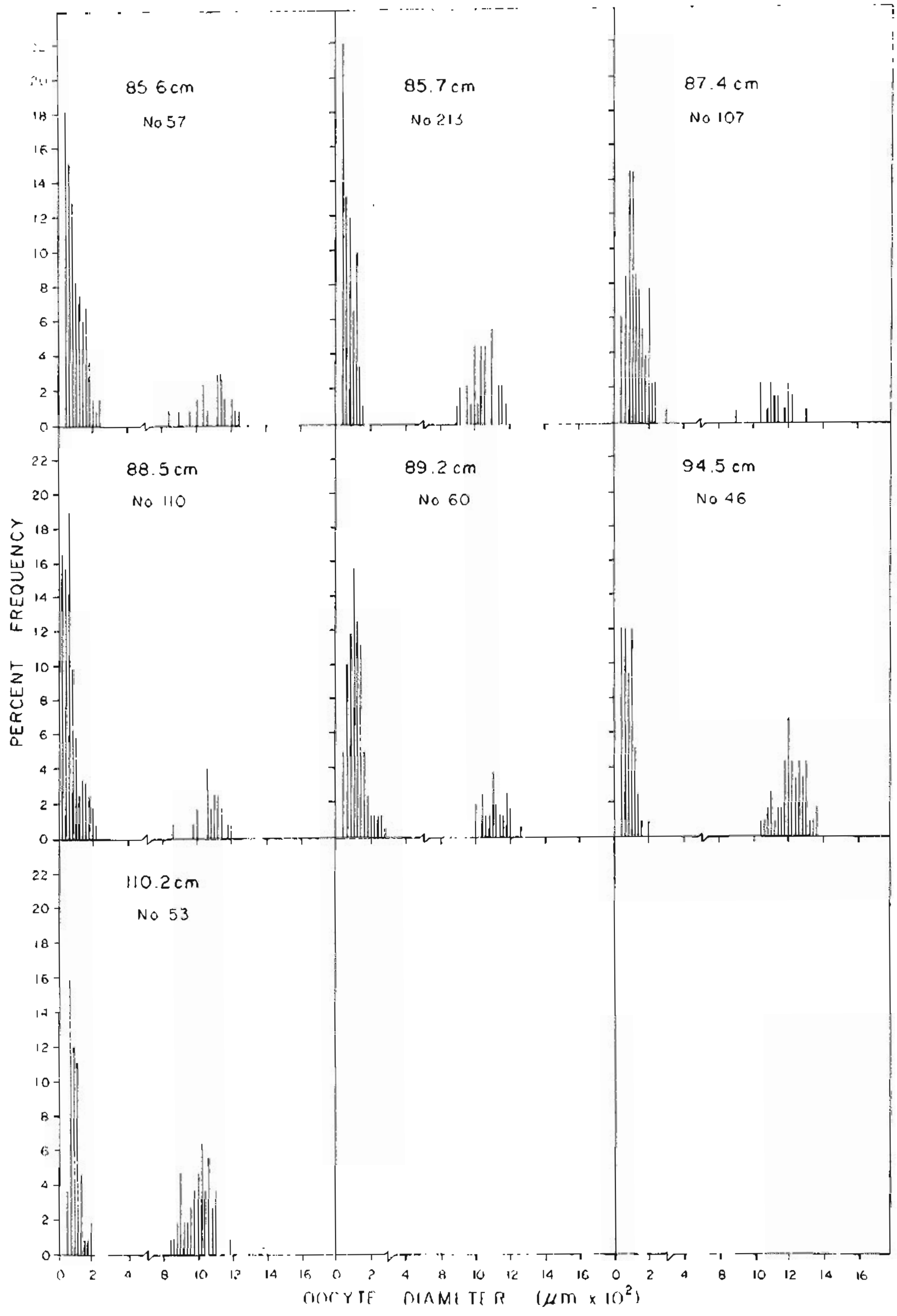

Fig. 4. Frequency distributions of oocyte diameters from ripe ovaries of sablefish 86-110 cm FL.

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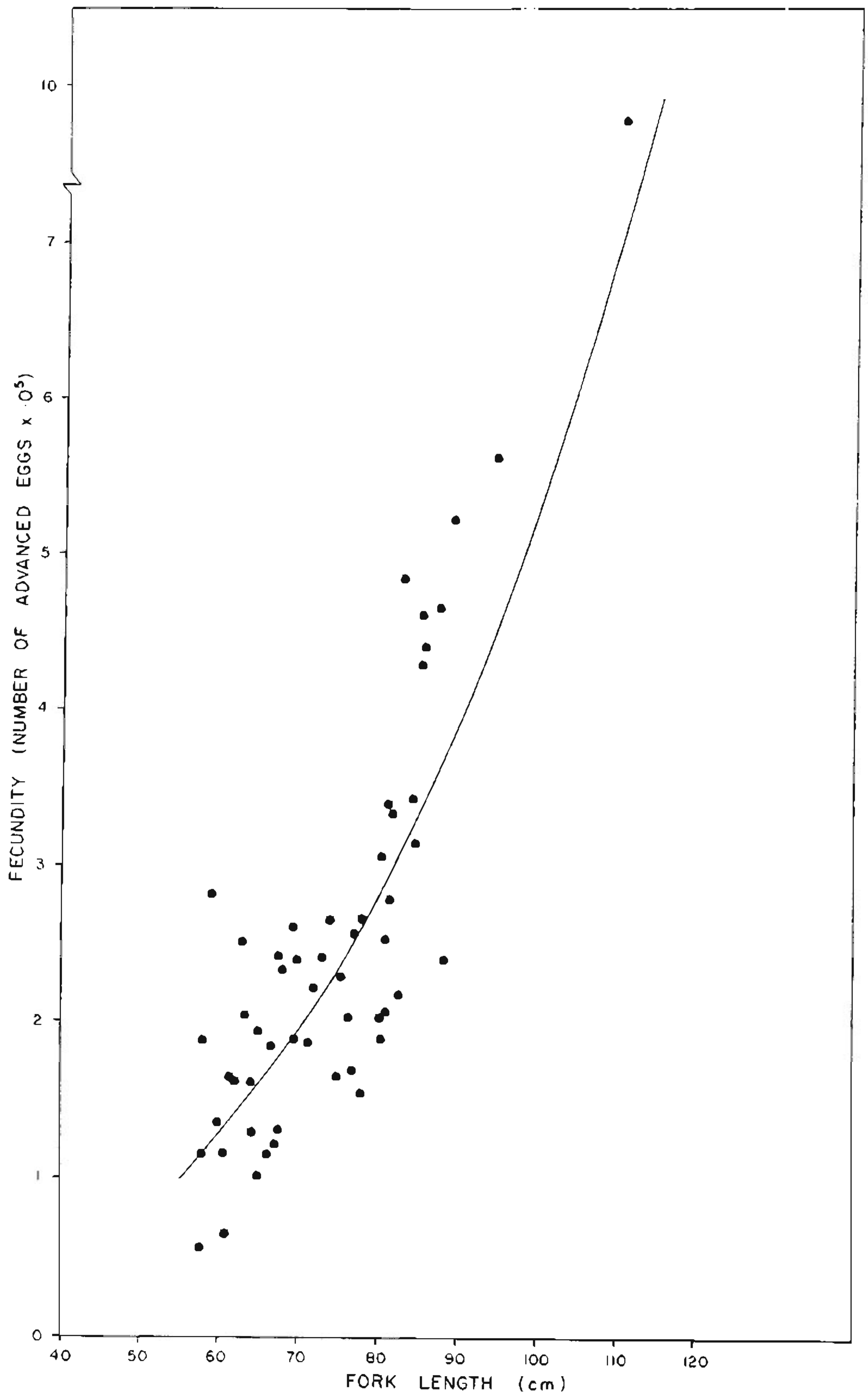

Fig. 5. Fecundity (no. advanced eggs) of sablefish from Canadian waters in relation to their fork length.

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