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Contributions to a Study of the Life History of the Hake. Spawning with Notes on Age Determinations.

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ABSTRACT

The commercial hake (Urophycis chuss (tenuis)) of the Atlantic Coast shows a typical teleostean gonad development for both male and female. The spawning season is definitely midsummer in the southern Gulf of St. Lawrence, probably early autumn off southeastern Nova Scotia and winter or spring at the mouth of the Bay of Fundy, as judged by a study of the ova maturity changes throughout the summer months of 1932. The onset of an increase in size of part of the ova varies inversely with the length of the specimen, the smaller the specimen the slower the onset.

Hake scales and otoliths may serve as methods of age determination.

CONTRIBUTIONS TO A STUDY OF THE LIFE HISTORY OF THE HAKE SPAWNING WITH NOTES ON AGE DETERMINATIONS

by

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INTRODUCTION

The so-called hake or ling of our Canadian Atlantic coast is a typical representative of the Gadidae, but probably because it is of slightly less value commerically than the cod and haddock with which it is usually associated, there has been comparatively little investigation of its general biology. Craigie, (1916), determined the rate of growth of the hake by scale examination and compared these data with the length frequency curves. Bigelow and Welsh, (1925), have provided a summary of the biology of the hakes, but this account is very generalized because of the meagre amount of data available. A brief record of the characteristics of the hake in Chesapeake Bay was made by Hildebrand and Schroeder, (1927).

It has generally been conceded that there are two closely related species of hake, the white hake, Urophycis tenuis (Mitchill, 1815) and the squirrel hake, Urophycis chuss (Walbaum, 1792) occurring on our coast. Of these the former has been considered the more abundant in the Fundy area (Huntsman, 1922). The most reliable distinguishing characteristics for the two species are taken as the size of scales on both head and body. There are 140 oblique rows of scales between the gill opening and base of the tail fin in U. tenuis, and seldom (if ever) more than 110 rows of scales in U. chuss. Owing to the fact that a great number of specimens appear to intergrade in scale number (120 to 135), until further more conclusive data is obtained it seems preferable to temporarily classify the hake by priority as U. chuss or as U. chuss (tenuis).

The data embodied in this paper represent the results of an investigation undertaken in the summer of 1932 at the Atlantic Biological Station, St. Andrews, N. B., at Digby, N. S., and the Eastern Passage Laboratory, N. S., with the purpose of enlarging our knowledge of the life history and habits of the hake in Canadian waters. Attention has been particularly focused on the developmental changes in the gonads with a view to ascertaining the spawning period.

Bigelow states (p. 452) that: "Practically nothing is known of the breeding habits of the white hake, but Welsh's examination of fish caught near Gloucester led him to conclude that spawning takes place in fall and winter and occasionally as late as April (he saw a male with milt flowing on April 22, 1913).

The egg is no doubt pelagic like that of the squirrel hake, but no ripe females, eggs, or young larvae have ever been seen."

In 1912 Bigelow trawled squirrel hake with running spawn in Ipswich Bay in July. The height of the season of this species falls in early summer in the Massachusetts bay region and at least as early as June south of Cape Cod. The season seems to be a long one from late spring until early autumn all around the Gulf of Maine from Cape Cod to Nova Scotia.

Hildebrand and Shroeder, (1927) state for U. chuss that it is quite certain that the ling spawns at least as far south as New Jersey, for fish distended with spawn were observed in April and May off Rockaway, N. Y. and Sandy Hook, although they have observed no ripe fish in Chesapeake Bay.

MATERIAL AND METHODS

During the summer of 1932 hake gonads were collected at St. Andrews, N. B., Digby, N. S., and Halifax, N. S. In early August fish were shipped in brine from Alberton, P. E. I. Most of the material was preserved in ten per cent formalin unless designed especially for cytological studies. The latter was fixed in a picro-formol-acetic mixture containing urea. Cedar oil was used in place of xylol as a clearing agent, but the material was placed in xylol for five minutes before putting in the paraffin bath. Two methods of staining were used, haematoxylin with eosin as a counter stain and Mallory's triple stain.

DEVELOPMENTAL STAGES IN GONADS

Since no description of the developmental changes in the ripening gonad is available in the literature the following arbitrary scheme has been drawn up similar to that used by Graham, (1923), for the cod and Bull, (1928), for the whiting.

A. MALE

I. Immature fish (See figures 1 and 2)

Testes appear as minute coiled whitish translucent coils grading to an almost transparent thread at the anterior end. This type of immature testis is characteristic of fish in their first three years. The histological section illustrated in figure 2 shows the thin-walled seminiferous tubules composed of large cuboidal cells seldom more than one or two layers in depth. The nuclei are large spherical structures practically all in a resting condition rather than in mitotic division.

II. Maturing fish (See figures 3 and 3a)

Testes in the maturing fish (fourth year on) appear as coarsely-coiled, translucent, white tubes with occasional slight pouch-like lobulations where

spermatogenesis is most active. In histological section the seminiferous tubules are seen to be composed of four or more layers of cells (spermatogonia and spermatocytes) with occasional patches in active division. Near the lumen of the tubules showing in gross the milky-white lobules, are clump-like masses of spermatids and spermatozoa. The lumen itself contains a scattering of spermatozoa with rounded heads and long flagella (10-12 microns in length).

III. Mature or "full" fish (See figures 4 and 5)

The testes in the mature fish are milky white in colour and consist of thick, much convoluted ribbons with distinct pouch-like lobules at frequent intervals along the length of the organ. In histological section, the walls of the seminiferous tubules are composed of spermatogonia and spermatocytes in active division and spermatids transforming into spermatozoa. The lumen is large and massed with mature spermatozoa.

IV. "Spent" fish (See figure 6)

The testes of a spent hake appear as shrivelled ribbons with the lobules represented by shrunken areas at frequent intervals along the organ. Unfortunately the only spent male hake obtained was among the brine-preserved lot from Alberton, P. E. I. This made it impossible to obtain a histological picture of the condition.

B. FEMALE

I. Immature fish (See figure 7, 8, and 9)

The ovaries in an immature fish (presumably generally less than four years) appear as white or cream coloured smooth-walled structures. In macroscopic transverse section, a fairly large lumen is present into which projects a number of thin-walled lamellae with thickened tips. The ova present are all small usually measuring from 0.01 mm. to 0.12 mm. in diameter. Figure 8 is a typical immature ovum showing the large vesicular nucleus with the few yolk-forming centres located about it. A microscopic section of an immature ovary (figure 9) reveals a mass of small ova held together between the stroma and grouped chiefly next the lumen along the margins of the lamellae.

II. Maturing fish (figures 10, 11, 12, 13, and 14)

In the maturing fish the ovaries become enlarged in diameter, more firm in consistency, and show gradually throughout the season an increasing distension, with a colour change from fawn to pink or reddish. In sectional area they appear solid with lamellae filling the lumen. The developing ova may be said to be of two size classes, small ova representing the type in the immature ovary (0.01 to 0.12 mm.) and ova in a further stage of development such as that shown in figure 11. This is typical of a group of ova which have increased approximately 0.10 mm. in diameter. The cytoplasm has become markedly greater in quantity than in the smaller ova (see figure 11) and the yolk granules are appearing more or less evenly spaced throughout the ovum. Microscopic examination of histological sections of maturing ovaries reveal structures as shown in figures 12 and 13. The immature and developing ova appear to be fairly evenly distributed throughout the

stroma of the ovary although there may be a slight tendency towary alignment of the maturing ova. In a single specimen in Halifax (figure 14) a few ova were massed with yolk granules and had acquired a heavy striated outer covering (zona radiata) at 0.39 mm.

III. Mature or "full" fish (See figures 15, 15a, 16, 17)

The ovaries of mature hake are strongly distended structures of a yellow to orange colour. They appear solid in sectional area with a slight indication of the remnants of lamellae and with many ova free in the lumen. The mature or nearly mature ova (figure 15a) measured from 0.49 to 0.70 mm. in diameter and were massed with irregular yolk granules within the heavy striated zona radiata.

We are dependent for our description of the histological structure of a mature or nearly mature ovary on a single 35 cm. specimen, quite definitely a squirrel hake, U. chuss, taken by trawl on August 17, 1932, off Joe's Point, St. Andrews. Squirrel hake are known to breed throughout the summer months and their ova are frequently taken then in Passamaquoddy bay with those of Enchelyopus cimbrius, the four-bearded rockling. In histological section this orange coloured gonad (figure 16, and 17) is seen to be composed of ova in varying stages of development, some minute (0.01 to 0.10 mm.) others intermediate in size (0.15 to 0.25 mm.) and still others yolk laden (0.30 to 0.49 mm.) and almost ready to burst free from the follicles. Figure 17 is a high power section of a single mature ovum showing the irregular yolk granules, the striated zona radiata and the surrounding follicular tissue. Located close to the mature ovum are very immature ova and an intermediate one in which yolk is collecting in the cytoplasm.

IV. "Spent" fish (figure 18)

Ovaries in the spent fish are whitish or cream coloured, flaccid, wrinkled structures with a firm fibrous outer covering. The lumen is large and the lamellae are thin with a few undischarged degenerating ova (0.49 to 0.70 mm. in diameter) filling the interspaces.

C. DISCUSSION

Hake were examined with regard to the state of gonad maturity, from the following localities:

1. Charlotte County, N. B. - specimens trawled from mud hake grounds, July 13, July 19, August 18, 24, 27th.

2. Halifax, N. S. - specimens trawled from Station 63, July 30th, September 8th.

3. Digby, N. S. - specimens trawled off Digby Neck, August 6th.

4. Prince County, P. E. I. - August 1st.

Using the data collected in the foregoing accounts as a basis for studying the maturity of hake, certain facts have come to the fore-ground and

have been further corroborated by evidence from a microscopic study of the hake ova. Briefly, in the summer of 1932 it was found that:

1. Gonads are immature in fish up to approximately four years of age (scale determination).

2. Adult hake are mature or spawning at the beginning of August off Prince County, P. E. I.

3. Hake gonads are maturing in late July off Halifax, N. S., but are not probably fully mature in early September.

4. In the Bay of Fundy the hake gonads show signs of a gradual development in July through August but are considerably delayed in development beyond those about Halifax.

5. The true squirrel hake, off Passamaquoddy bay, matures in midsummer.

It would seem then that we might tentatively predict the spawning period of the hake as follows:

a) midsummer in the southern Gulf of St. Lawrence
b) autumn off southeastern Nova Scotia
c) winter or early spring in the Fundy area

It remains yet to correlate these predictions with temperature and to establish any possible relationships therewith.

HISTORY OF THE OVUM

To assure a more complete picture of the history of the hake ovum interpretations were based largely on measurements of the rate of growth of developing ova from a large number of females. Ova were measured by an eye-piece micrometer in a compound microscope. A small section of an ovary was teased out on a slide ruled in squares. A ten per cent solution of formaldehyde was then added to moisten the surface and the eggs were gently probed to break up the clumps. No allowance was made for shrinkage of the ova in preservation since all material examined had been treated in exactly the same manner. The diameters of 200 ova were measured from each specimen and where possible five specimens within a definite length group were used making a total of 1,000 eggs in each instance. To safeguard against measuring the same ovum more than once, the eggs of one square were all measured before proceeding to the next square.

In an effort to determine if differences existed in the state of maturity of eggs in different regions of the ovary, diameters of 200 ova were taken from each of four regions in a typical early-maturing ovary from a 65 cm. hake (Campobello, N. B., July 19, 1932). The results of these measurements are shown in table I and each series is plotted in a frequency curve, (figure 19). The four curves for A - tip of ovary, B - mid region of ovary, C - junction of ovaries, D - posterior region of ovaries, when compared, do not differ any more than do any two curves obtained by the same method of measurements. However, for purposes of

uniformity the mid region B was chosen as standard for further measurements.

Clarke, (1925), showed for Leuresthes tenuis that measurement of any chance axis of an ovum gave the same type of frequency curve as that obtained by averaging the greatest and least diameters. To test out the dependability of this method for the hake, measurements were made of the maximal and minimal diameters of 200 ova, and of the chance diameter of a similar number of ova from a 68 cm. hake taken at Campobello, N. B., on August 18, 1932. Table II gives the results of these two sets of measurements, the maximal and minimal diameters being averaged. Figure 20 shows by a continuous line the frequency curve compiled for the average of the maximal and minimal diameters, while the discontinuous line is the frequency curve compiled from the measurements of ova whose axis were determined by the chance relation of the position of the ovum to the eye-piece micrometer. These curves are so similar in type that it was considered sufficiently accurate to make future measurements of whatever diameter chanced to be parallel to the micrometer scale.

Hake ova measurements were made from fish taken in various representative localities as previously enumerated. The results are given in detail in tables III, IV, V, and VI and frequency polygons are represented in figure 21.

Hake may be divided into four size classes:

50 - 57 cm.
58 - 65 cm.
66 - 72 cm.
73 - 80 cm.

This seemingly arbitrary division is based wholly on the size of ova contained in the gonads. In the first class we find (table III) ova in all localities studied at all seasons ranging from 0.01 to 0.13 mm. in diameter, with (figure 21) maximal numbers from 0.05 to 0.08 mm. Using Charlotte County as a basis it would seem that these fish represent the immature class, which will not be mature during the subsequent spawning season, since practically no increase in size took place during the summer season.

In the second class 58 - 65 cm. (table IV), ova ranged from 0.01 to 0.13 mm. in diameter on July 13th and progressively increased until some had attained a diameter of 0.23 mm. on August 27th. Figure 21 shows that the single immature class of July 13th with a peak at 0.06 to 0.07 mm. has gradually divided into two classes, a permanent immature group and a maturing group with peaks at 0.11, 0.13, and 0.15 mm. on July 19th, August 18th, and August 27th respectively. At Digby on August 6th the same two groups are indicated with the immature peak at 0.07 mm., the maturing at 0.14 mm. The Prince County, P. E. I., specimens (2) were in a spent condition and contained only immature ova ranging from 0.01 to 0.08 mm. with a peak at 0.04 mm. On July 30th the Halifax specimens were as mature as those taken in Charlotte County on August 27th ranging from 0.01 to 0.23 mm. with peaks for immature ova at 0.05 mm. and for maturing ova at 0.16 mm.

Examining the data for the third group (66 to 72 cm.) in table V and figure 21, we find for Charlotte County on July 13th ova vary in size from 0.01 to 0.15 mm. and are showing signs of dividing into two groups with peaks at 0.06

to 0.07 mm. and 0.12 to 0.13 mm. Little change is noted on July 19th, but by August 18th a few ova have attained a diameter of 0.25 mm. and there are two more or less intergrading groups with peaks at 0.07 mm. and 0.19 mm. These two groups have become more distinct by August 27th with the maturing peak advanced to 0.21 mm. and the maximal ovum diameter 0.29 mm. The Digby group on August 6th resembles that for Charlotte County on August 18th. The Prince Edward Island specimens once more contrast with all others along the coast, for they contain two distinct groups, immature (0.01 to 0.10 mm.) ova and degenerating mature ova (0.49 to 0.70) mainly from the lumen of the almost spent gonads. As in the previous class (58 to 65 cm.) the Halifax specimens on July 30th are as advanced in maturity as the Charlotte County hake one month later (August 27th). Immature ova with a peak number at 0.06 mm. are present along with maturing ova up to 0.28 mm. with a maximum at 0.21 mm.

Data from the larger size hake (73 to 80 cm.)have been tabulated in table VI and frequency curves plotted in figure 21. For Charlotte County, immature and maturing ova are present on July 13 with maximum numbers at 0.06 mm. and 0.14 mm. By July 19th the maturing group has increased to a maximum of 0.21 mm. with a peak at 0.15 mm. The peak of immature ova is at 0.07 mm. on August 18th and of the maturing at 0.22 mm. with a maximal diameter of 0.27 mm. The immature group remain stationary during the ensuing week to August 27th but the maturing group is predominant at 0.26 mm. and reaches a maximum diameter of 0.33 mm. corresponding to the specimens taken on July 30th at Halifax. In the latter instance the immature ova are found in greatest numbers at 0.08 mm. and the maturing at 0.25 mm. with a maximum diameter of 0.31 mm. The Digby group for August 6th is scarcely as advanced as that for Charlotte County on August 18th, but two groups are evident, the immature with a peak number at 0.05 mm., the maturing at 0.21 mm. with a maximal diameter of 0.25 mm.

It is unfortunate that no mature U. chuss (tenuis) except the nearly-spent brine-preserved Prince Edward Island specimens were available to make a direct comparison with the immature and developing ovaries. Counts, however, were made on the mature ovary of U. chuss taken on August 17th and showed three groups of ova; immature peak at 0.06 mm. diameter; maturing peak at 0.18 mm.; almost mature peak at 0.36 mm.; maximal diameter 0.48 mm.

Briefly we may summarize as follows:

1. Hake from 50 to 57 cm. contain only immature (0.01 to 0.13 mm.) ova in the ovaries and show no signs of an early maturity.

2. Off Charlotte County by late August hake over 57 cm. in length contain ova of an immature and maturing (intermediate) groups (0.14 to 0.30 mm. approximately).

3. Off Prince County, P. E. I., spawning takes place in midsummer as indicated by the presence of only immature and degenerating ova in a shrivelled ovary.

4. At Halifax in late July, hake have progressed in maturity as far as those at Charlotte County in late August.

5. Hake taken off Digby appear to mature slightly sooner than those off Charlotte County.

6. The time of the onset of maturity as indicated by the increasing size of part of the ova depends to some extent on the size (age) of the fish, the larger the earlier the onset.

7. Mature U. chuss contains ova of three different size groups, immature, intermediate or maturing and mature.

8. The immature group of ova persist in the gonad of all fish but the maturing (intermediate) only seem to be present as an indication of approaching maturity.

METHODS OF AGE DETERMINATION

Otoliths were removed at random from the inner ear of hakes and attempts were made to read the age after preparing transverse sections by polishing. Figure 22 shows a typical otolith from a 48 cm. female hake. The section illustrates that there is some possibility of aging the fish from the annual, and this one (3 years old) checked definitely with the scale count. At either end of the otolith sections are valueless but in the exact mid-region sections can be used for aging a fish although the method is less convenient than the scale one.

Hake scales (Craigie, 1916), have already been shown to be useful for age determinations, although they differ from those of other fish in that there is no true succession of spiral, cyclic, or crescentic rings. The nucleus is elliptical in outline (figures 23, 24) with a break toward the anterior end of the scale. These parallel ellipsoidal circuli are seen to be spaced evenly to the margin of the scale, but the outer or lateral ones are incomplete. The annual rings are often indefinite and are the result of two factors, a little irregularity in the rings and roughened areas in the scale structure. Figure 23 shows the scale from the side of a 9.3 cm. hake presumably in its first year taken near Halifax at Tuft's Cove, July 26, 1932. Figure 24 represents a scale from a 56 cm. female in its fourth year taken at Campobello, N. B., July 19, 1932.

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SUMMARY

1. The Atlantic coast hake (Urophycis chuss (tenuis)) shows typical teleostean gonad changes with development.

2. The testis in immature hake is a finely-coiled, translucent, white thread, on maturity it becomes a lobulated, convoluted milky-white ribbon. The spent testes appears shrivelled.

3. Immature testes of the hake possess only one or two layers of cuboidal cells in the walls of the seminiferous tubules. Mature testes have a many-layered wall in the seminiferous tubule with evidences of active cell division, and minute spermatozoa free in the lumen.

4. The ovary of the hake is a more or less soft, smooth-walled, cream-coloured organ in the immature condition, but becomes pink to orange as ova mature, accompanied by a firming up of the whole organ. The spent ovary is a shrivelled structure with a large central lumen.

5. Immature ovaries contain only immature ova (0.01 to 0.13 mm. in diameter) imbedded in the stroma and usually bordering on the lumen between the lamella. Maturing ovaries possess ova of two size classes, the immature and maturing (intermediate - 0.14 to 0.30 mm. in diameter). Immature ova possess a large vesicular nucleus and few yolk granules. Maturing ova have a correspondingly greater cytoplasmic content and many yolk granules. Mature ova are bounded externally by a heavy striated zona radiata and are massed with large-sized yolk granules.

6. A study of hake ova frequency curves indicates that there is apparently no one spawning period for the Atlantic coast hake. Hake spawn in midsummer off Prince Edward Island, but are only maturing at that time off Halifax preparatory to spawning in the autumn. In the Fundy Area they are about a month or more late in development than off Halifax. Spawning probably takes place during the winter or spring. This progression of spawning may be correlated with temperature.

7. Hake scales and otoliths may be used for age determinations.

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TABLE I

Diameters of Ova - 65 cm. Hake

Campobello, N. B., July 19, 1932

Diameters of Ova	Regions of Ovary			
	Anterior (A)	Mid (B)	Junction (C)	Posterior (D)
.01	8	8	12	10
.02	14	15	10	17
.03	10	14	10	9
.04	19	14	19	14
.05	18	20	21	23
.06	18	20	26	22
.07	7	8	10	10
.08	5	5	3	5
.09	12	4	2	9
.10	24	23	17	15
.11	20	25	22	21
.12	29	26	35	28
.13	5	6	2	3
.14	8	7	3	8
.15	3	5	8	5
.16	0	0	0	1
Total	200	200	200	200

TABLE II

Diameters of Ova - 68 cm. Hake

Campobello, N. B., August 18, 1932

	Numbers of Ova	Measurements
Diameter mm.	Average of 2 axes	Chance axis
.01	6	4
.02	8	4
.03	11	12
.04	14	7
.05	10	8
.06	11	14
.07	6	4
.08	5	6
.09	6	7
.10	10	12
.11	8	14
.12	14	10
.13	11	8
.14	8	12
.15	9	6
.16	15	18
.17	10	8
.18	21	10
.19	24	18
.20	6	3
.21	4	4
.22	1	0
.23	2	1
.24	1	0
Total	200	200

TABLE III

Diameters of Hake Ova - 1932

Measurements of 200 ova from five specimens

50-57 cm. in length

	Locality					
	St. Andrews, N. B.				Digby, N.S.	Halifax, N.S.
Diameter mm.	July 13	July 19	Aug. 18	Aug. 27	Aug. 1	July 30
.01	27	20	48	14	37	17
.02	41	12	56	29	25	39
.03	80	37	43	29	10	41
.04	32	120	79	37	82	152
.05	220	256	136	108	137	199
.06	76	198	372	316	291	243
.07	200	133	100	282	122	102
.08	150	172	98	93	121	153
.09	100	35	22	106	44	25
.10	30	14	10	12	73	12
.11	40	3	36	3	42	---
.12	3	---	---	---	15	10
.13	---	---	---	---	1	7
Total	1,000	1,000	1,000	1,000	1,000	1,000

TABLE IV

Diameters of Hake Ova - 1932

Measurements of 200 ova from five specimens

58-65 cm. in length

	Locality						
	St. Andrews, N. B.				Digby N.S.	Alberton P.E.I.	Halifax N.S.
Diameter mm.	July 13	July 19	Aug. 18	Aug. 27	Aug. 6	Aug. 1 (?)	July 30
.01	33	61	12	16	12	21	8
.02	24	25	17	10	32	67	17
.03	19	51	16	27	12	82	57
.04	98	105	67	69	--	136	33
.05	174	100	89	91	10	62	99
.06	204	159	101	59	34	21	72
.07	199	25	52	58	97	10	34
.08	99	76	17	52	72	1	25
.09	72	108	44	27	58		10
.10	15	97	27	21	41		40
.11	42	133	60	14	32		6
.12	10	27	103	53	46		47
.13	11	4	150	57	87		56
.14		20	113	79	201		22
.15		9	70	206	127		84
.16			28	107	52		125
.17			23	23	45		77
.18			9	10	27		69
.19			1	9	6		74
.20			1	7	8		24
.21				2	1		10
.22				1			9
.23				2			2
Total	1,000	1,000	1,000	1,000	1,000	400	1,000

TABLE V

Diameters of Hake Ova - 1932
Measurements of 200 ova from five specimens
66-72 cm. in length

	Locality						
	St. Andrews N.B.				Digby N.S.	Alberton P.E.I.	Halifax N.S.
Diameter mm.	July 13	July 19	Aug. 18	Aug. 27	Aug. 6	Aug. 1 (?)	July 30
.01	19	27	15	10	15	37	7
.02	26	14	--	26	26	33	19
.03	9	24	12	--	36	42	47
.04	21	30	16	17	10	65	23
.05	54	105	42	43	21	70	38
.06	126	34	59	21	69	2	129
.07	128	116	63	111	104	2	76
.08	162	59	--	70	21	1	42
.09	83	55	27	42	30	1	57
.10	97	68	85	29	45	2	38
.11	50	106	41	57	67		50
.12	98	82	57	17	3		14
.13	105	151	53	--	31		10
.14	15	90	99	33	45		16
.15	7	32	67	28	--		51
.16		7	24	15	67		27
.17			26	17	49		52
.18			62	29	53		21
.19			153	53	68		14
.20			47	97	128		25
.21			35	117	73		103
.22			12	108	22		100
.23			3	37	4		31
.24			1	5	5		1
.25			1	12	8		4
.26				--			3
.27				1			1
.28				3			1
.29				2			
.49						9	
.50						15	
.51						20	
.52						29	
.53						11	
.54						9	
.55						7	
.56						4	
.57						5	
.58						1	
.59						5	
.60						1	
.61						1	
.62						5	
.63						2	

TABLE V continued-

.64						1	
.65						1	
.66						4	
.67						2	
.68						3	
.69						3	
.70						6	
Total	1,000	1,000	1,000	1,000	1,000	400	1,000

TABLE VI

Diameters of Hake Ova - 1932

Measurements of 200 ova from five specimens

73-80 cm. in length

	Locality					
	St. Andrews, N. B.				Digby, N. S.	Halifax, N. S.
Diameter mm.	July 13	July 19	Aug. 18	Aug. 27	Aug. 6	July 30
.01	15	3	7	6	5	11
.02	18	12	5	13	14	9
.03	13	24	18	11	11	14
.04	92	49	8	23	27	18
.05	98	73	29	54	73	29
.06	134	126	56	67	52	47
.07	76	58	111	106	17	78
.08	34	94	53	32	8	101
.09	43	26	36	37	14	43
.10	20	17	12	38	3	22
.11	37	11	9	--	4	20
.12	33	73	2	43	7	9
.13	42	109	22	12	2	7
.14	128	103	27	9	1	15
.15	59	128	38	6	9	22
.16	121	35	29	11	15	37
.17	25	27	48	5	7	14
.18	12	14	41	8	1	16
.19		11	53	23	4	19
.20		5	59	27	8	27
.21		2	77	21	73	43
.22			100	33	26	52
.23			69	53	15	51
.24			50	60	3	73
.25			28	77	1	99
.26			8	91		61
.27			5	42		46
.28				30		2
.29				25		5
.30				18		8
.31				4		3
.32				12		
.33				3		
Total	1,000	1,000	1,000	1,000	400	1,000

The following figures are on file at St. Andrews:

Figure 1. Thread-like immature testis of a 46 cm. male hake. (Campobello, N. B., July 19, 1932.) Actual length 14 cm.

Figure 2. Histological section of an immature hake testis from a 46 cm. male. (Campobello, N. B., July 19, 1932.)

Figure 3. Maturing testis of a 59 cm. hake (St. Andrews, N. B., August 27, 1932). Actual length 15 cm.

Figure 3a. Histological section of a maturing hake testis from a 59 cm. male. (St. Andrews, N. B., August 27, 1932.)

Figure 4. Mature testis of a 70 cm. male hake. (Alberton, P. E. I., July 25, 1932.) Actual length 16 cm.

Figure 5. Histological section of a mature hake testis from an 86 cm. male. (Halifax, N. S., July 30, 1932.)

Figure 6. Spent testis of a 66 cm. male hake. (Alberton, P. E. I., July 25, 1932.) Actual length 15 cm.

Figure 7. Ovary from a 51 cm. female hake containing only immature ova, gross and in macroscopic section. (Halifax, N. S., July 30, 1932.) Actual length 9 cm.

Figure 8. Immature hake ovum from 55 cm. female hake. (St. Andrews, N. B., July 5, 1932.) Diameter .05 mm.

Figure 9. Histological section of an immature ovary of a 54 cm. female hake. (St. Andrews, N. B., July 19, 1932.)

Figure 10. Maturing ovary, gross and macroscopic section from a 65 cm. female hake (St. Andrews, N. B., August 18, 1932). Actual length 10.5 cm.

Figure 11. Developing hake ovum from a 69 cm. female. (St. Andrews, N. B., July 19, 1932.) Diameter .15 mm.

Figure 12. Histological section of a maturing ovary from a 72 cm. female hake. (Halifax, N. S., July 30, 1932.)

Figure 13. Histological section of a maturing ovary from a 71 cm. female hake. (St. Andrews, N. B., August 27, 1932.)

Figure 14. Maturing hake ovum from a 71 cm. female. (Halifax, N. S., July 30, 1932.) Diameter .39 mm.

Figure 15. Mature ovary gross and macroscopic section from a 67 cm. female. (Alberton, P. E. I., July 25, 1932.) Actual length 11.5 cm.

Figure 15a. Mature (?) hake ovum from a 69 cm. female. (Alberton, P. E. I., July 25, 1932.) Diameter 55 mm.

Figure 16. Histological section of the ovary of a 35 cm. female hake taken August 17, 1932, off Joe's Point, St. Andrews, N. B.

Figure 17. High power section of the ovary shown in figure 16. Note the immature, maturing and mature ova.

Figure 18. Spent ovary, gross and macroscopic section, from a 68 cm. female. (Alberton, P. E. I., July 25, 1932). Actual length 11 cm.

Figure 19. Frequency curves of ova diameters taken from four different regions of the ovary of a 65 cm. female hake. (Campobello, N. B., July 19, 1932.

Figure 20. Frequency curves of 200 ova diameters from a 68 cm. female hake, taken at Campobello, N. B., August 18, 1932. Unbroken lines refer to the average of measurements of the greatest and least diameters; broken lines refer to measurements whose axes were determined by the chance relation of the position of the ovum to the eye piece micrometer.

Figure 21. Frequency polygons of the diameters of ova measured from hake taken at St. Andrews, N. B., Digby, N. S., Halifax, N. S. and Alberton, P. E. I. during the summer of 1932.

Figure 22. Otolith of a 48 cm. female hake, gross and macroscopic section. The section illustrates that there is some possibility of aging the fish from the annuli. (Campobello, N. B., July 5, 1932.)

Figure 23. Hake scale taken from the side of a 9.3 cm. specimen just ventral to the dorsal fin, midway between the anus and the tip of the tail (July 26, 1932, Tuft's Cove, N. S.). Note the evenly spaced circuli.

Figure 24. Hake scale from a specimen in its fourth year (56 cm., female, July 19, 1932, Campobello, N. B.). Note the roughened areas and irregularity of the circuli at the annual rings.