Northeast Fisheries Science Center Reference Document 94-13

Atlantic Sea Scallop *Placopecten magellanicus*, Maturation on Georges Bank During 1993

by

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ABSTRACT

Sea scallop gonad samples collected by U.S. commercial scallop vessels fishing Georges Bank during January-August 1993 were analyzed macroscopically and histologically to determine maturity stage and time of spawning on the bank. Reports of a possible winter-early spring spawn on Georges Bank prompted the analysis, which has important biological and management implications.

The analyses indicated a general progression from early developmental stages in winter-early spring to ripe in July-August. Gonadosomatic indices indicated a steady progression of maturation during July-August. There was, however, a single male scallop, collected south of Martha's Vineyard in early February, that appeared to be actively spawning and two females collected from the Great South Channel area east of Chatham, Mass. in early May in a late developing stage. It is not known whether these three scallops were contributing to a spring spawn in the Southern New England area or on Georges Bank, or were simply maturing earlier during 1993 in response to environmental conditions.

INTRODUCTION

During the winter of 1993, possible sea scallop, *Placopecten magellanicus*, spawning activity on Georges Bank was reported by a commercial fishing vessel hailing from New Bedford, Massachusetts. Previous data indicated that the spawning period for scallops inhabiting Georges Bank was during the late summer or early autumn (Posgay and Norman 1958, MacKenzie *et al.* 1978). However, recent studies indicate that during some years there are two distinct spawns, one during the spring and a second, major event in the late summer or early autumn (DiBacco 1993). Because of this, an analysis of samples from this fishery was significant both in terms of the management of the species and the aging method used. Scallop age determinations use shell rings, but this method has been confounded by reports that ring formation was accomplished either during winter-early spring, corresponding to the period of minimum water temperature (Stevenson and Dickie 1954, Tan *et al.* 1988, Dare and Deith 1989), or during both the winter and the spawning period (Krantz *et al.* 1984, DuPaul *et al.* 1989) depending on the area from which scallops were obtained.

This report describes the results of maturation studies conducted on samples collected by U.S. commercial scallop vessels fishing the Georges Bank region during January-August 1993.

METHODS

Scallops were collected during routine commercial fishing operations by the *F/V Nordic Pride* and *F/V Andrea Jean* from New Bedford, Mass., during January-May 1993, and six other vessels during July-August 1993, and transported live to the Northeast Fisheries Science Center's (NEFSC) Woods Hole Laboratory shortly after each sample was brought to port. Sampling locations and dates are provided in Table 1 and Figure 1. All gonads collected during January-May (n=37), and a random sample of those from July-August (n=22), were processed and examined histologically to determine maturity stage. July-August samples were also examined macroscopically using criteria from Naidu (1970). Shell height (millimeters) and sex were taken from samples collected January-May 1993. In addition, total, gonad, meat, and visceral weights (0.1 g) were obtained from each scallop collected during July-August. Histological analyses were performed by excising a 1 cm cube of the gonad and fixing the sample in 10% buffered formalin in seawater. Samples were then embedded in paraffin, sectioned, mounted, and stained with hematoxylin and eosin. The slides were examined under a compound microscope at 40x magnification. The criteria used to assign maturity stage to each sample were from Naidu (1970).

Gonadosomatic indices (GSIs) were derived according to the following expression:

$$GSI = \textit{arcsine}(\text{gonad weight}/(\text{gonad weight}+\text{meat weight})).$$

This expression, using gonad plus meat weight rather than visceral weight in the denominator, was used in order to compare values obtained from this analysis to previously calculated indices for scallops collected on Georges Bank during 1987-1988 (unpublished NEFSC data).

Table 1. Summary of live sea scallop collections from cooperative U.S. fishery catches used in evaluation of maturation schedules during 1993

Vessel	Sample ID	Sample Size	Date Landed	Location
F/V Nordic Pride	D	5	Jan 3	Southeast Part
"	B	6	Feb 3	South of Martha's Vineyard
"	A	3	Apr 4	Southeast Part
"	F	4	Apr 20	Northern Edge
"	G	3	Apr 21	Southeast Part
"	C	4	Apr 23	Great South Channel
"	H	4	Apr 30	Northern Edge
F/V Andrea Jean	E	10	May 4	East of Chatham, Mass.
F/V Resolute	I	12	Jul 6	Southeast Part
F/V Mary Anne	N	7	Jul 7	"
F/V Edgartown	J	13	Jul 18	"
F/V Nordic Pride	K	12	Jul 21	Great South Channel
F/V Ambassador	L	16	Jul 22	Southeast Part
F/V Mary Anne	M	6	Jul 27	"
F/V Majestic	O	17	Aug 2	"
F/V Resolute	P	12	Aug 10	"
F/V Ambassador	Q	14	Aug 10	"
F/V Prospector	R	21	Aug 16	"

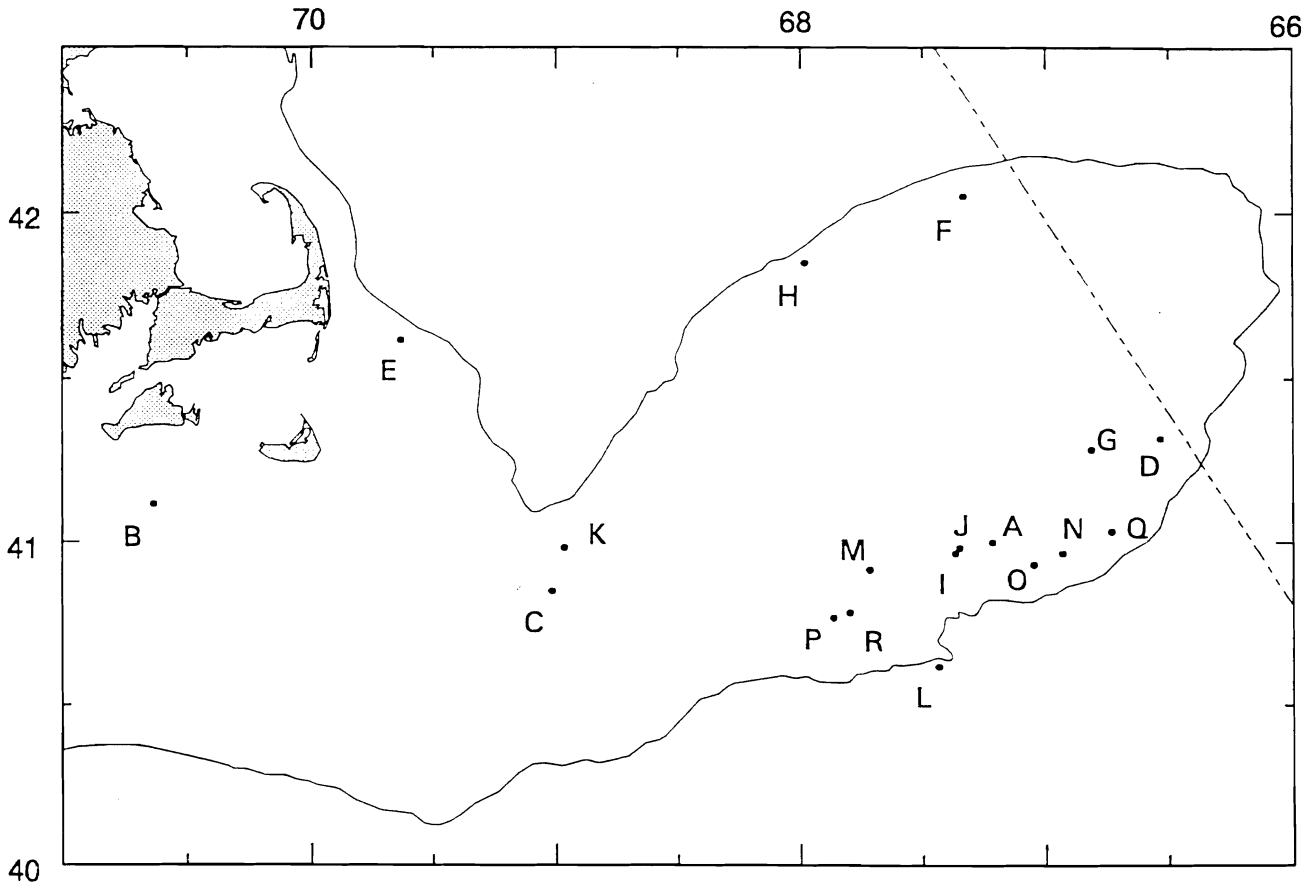

Figure 1. Sampling locations of sea scallops collected during commercial fishing operations during January-August 1993. Letters represent sample identification codes listed in Tables 1 and 2.

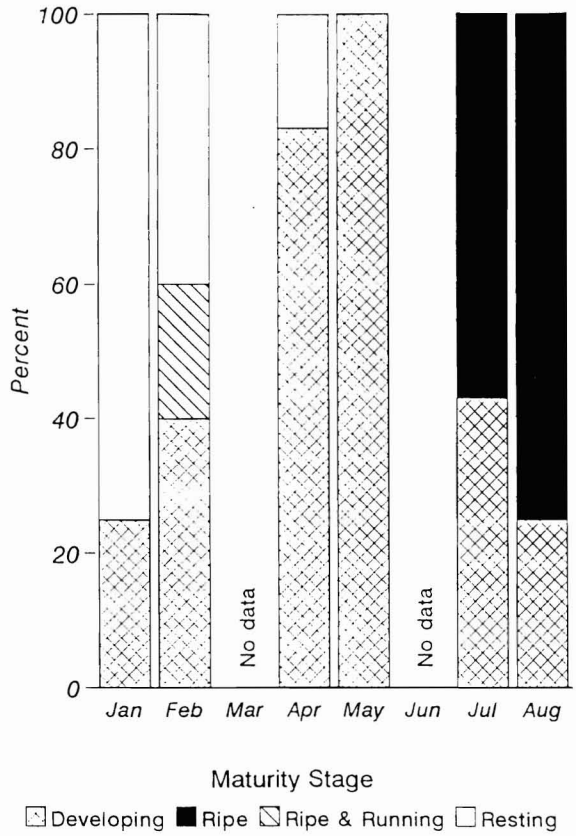

Figure 2. Distribution (by percent) of maturity stages determined through histological examination of sea scallops collected in the Georges Bank area during 1993.

RESULTS

We examined 169 scallops, 59 of which were processed for histological evaluation. Most samples were obtained from the southeast part of Georges Bank, with two each from the Northern Edge and Great South Channel. There were also single samples obtained from the area south of Martha's Vineyard and east of Chatham, Mass. (Table 1, Figure 1). Thirty-nine scallops were collected during the winter/spring seasons, while the remaining 130 were collected during the summer months (Table 1). Shell heights ranged from 74 to 142 mm.

MATURATION

Histological examination of gonads indicated that as the year progressed, there was a steadily increasing proportion classified as developing, from 25% in January to 100% by May (Figure 2). During this time, all other scallops were in a resting stage with the exception of one male collected in February south of Martha's Vineyard that was considered to be actively spawning, and two females in a late developing stage collected from the Great South Channel area east of Chatham, Mass. in early May.

By July, 43% of the scallops were classified as developing with 57% now ripe; by August, only 25% were developing with the remaining 75% ripe. This indicated that spawning was about to take place, probably during late August-September.

GONADOSOMATIC INDICES

Gonadosomatic indices calculated by sex for July and August indicated that there was little variability between sexes in each month, (0.299 versus 0.319 for males and females, respectively in July, and 0.365 versus 0.362 in August; see Tables 2 and 3).

The results showed that while GSIs were more variable in July (CV=27.4% for sexes combined) than during August (CV=18.2%), it is clear that maturation was increasing during the sampling period. These values were comparable to those obtained during monthly sampling on the Bank during 1987-1988 (unpublished NEFSC

data) and indicated that spawning was about to commence.

MACROSCOPIC VERSUS HISTOLOGIC CLASSIFICATIONS

In order to compare macroscopic and histological classifications of the gonads, it was necessary to combine several histological stages, as indicated in Table 4.

A comparison between the two methods was possible for 22 gonads (10 males and 12 females) collected during July-August. Of the 22, 10 of the gonads (2 males and 8 females) classified as developing from macroscopic examination were classified as Stage VII under histological examination. This indicated that at the cellular level, the gonads were further developed than was evident macroscopically, especially for females during July and early August.

Table 2. Gonadosomatic indices calculated by sex for scallops collected in July and August, 1993

	Males	Females	Sexes Combined
	July		
Mean	0.299	0.319	0.310
CV	27.8	27.0	27.4
Minimum	0.08	0.17	0.08
Maximum	0.46	0.53	0.53
Sample Size	29	37	66
	August		
Mean	0.365	0.362	0.363
CV	17.0	19.3	18.2
Minimum	0.25	0.23	0.23
Maximum	0.48	0.49	0.49
Sample Size	33	31	64

DISCUSSION

Off the northeastern coast of the United States, scallop reproductive biology is variable depending upon region. DuPaul *et al.* (1989) and Kirkley and DuPaul (1991) provided evidence that scallops inhabiting the Middle Atlantic region may spawn twice each year but with wide variability depending on environmental conditions; a major event taking place during the spring and an additional autumn spawning period. As in this study, the initial samples provided for their analysis were provided by the *F/V Nordic Pride*.

In the northern portions of their range, scallop spawning has generally been reported to occur during the late summer and early autumn. For instance, in the Gulf of Maine and Bay of Fundy, several reports have indicated that spawning occurs during September-October (Drew 1906, Stevenson 1936, Welch 1950, Posgay 1950). In Newfoundland, spawning also generally occurs in September-October (Naidu 1970).

Posgay and Norman (1958) reported that the peak spawning period is during early autumn on the Northeast Peak of Georges Bank. They also indicated that during some years, spawning took place over a very short period with individuals from an entire bed progressing from ripe to spent in about one week. DiBacco (1993) examined GSIs from a monthly sampling program during 1984-1991, gonad histology from samples collected during 1990-1991, and plankton data from May 1991 from the Northeast Peak of Georges Bank. He concluded that scallops may spawn twice a year on the Bank, with the major spawn occuring in the late summer to early autumn and a minor spawn in the spring, although the spring spawn was erratic and did not occur in some years (*e.g.* 1989).

The results of the macroscopic and histological examinations presented in this study, using samples collected over a wide area of the bank, suggested an early autumn spawn on Georges Bank. Highly synchronized spawning may take place during some years while in others the spawning period may be protracted, with individuals developing to the ripe stage at different rates, probably depending on environmental conditons. Once at the ripe stage, the scallops may remain stable until a mechanism triggers spawning to occur; this trigger remains unknown. If this is the case, it is possible that the two female scallops characterized as late developing (histological Stage VI/VII) in the May sample may have contributed to a minor spring spawn or may have remained at this advanced stage until autumn.

In order to maximize yield per recruit from any fishery, a clear understanding of the reproductive process is necessary. Cooperative efforts between the commercial fishing industry and biologists such as the one described in this report are vital to that understanding.

Table 3. Scallop gonad samples collected from Georges Bank during January-August 1993, examined by histological and macroscopic methods

Sample ID	Date	Shell Height (mm)	Sex	Maturity Stages[1]		GSI
				Macro	Histo	
D1	3 Jan	82	F	-	IV	-[2]
D5	3 Jan	86	F	-	IV	-
D2	3 Jan	86	F	-	IV	-
D4	3 Jan	87	M	-	III	-
B2	3 Feb	76	F	-	II	-
B4	3 Feb	80	M	-	VI	-
B5	3 Feb	87	M	-	VI	-
B1	3 Feb	88	M	-	VIII	-
B6	3 Feb	90	M	-	VI	-
F3	20 Apr	97	F	-	VI	-
F1	20 Apr	97	F	-	VI	-
F2	20 Apr	99	M	-	VI	-
F4	20 Apr	100	M	-	VI	-
G1	21 Apr	97	F	-	V	-
G3	21 Apr	113	F	-	V	-
G2	21 Apr	108	M	-	IV	-
A3	22 Apr	115	F	-	V	-
A1	22 Apr	118	F	-	IV	-
A2	22 Apr	107	M	-	IV	-
C1	23 Apr	86	F	-	VI	-
C4	23 Apr	86	F	-	VI	-
C3	23 Apr	86	M	-	VI	-
C2	23 Apr	89	M	-	VI	-
H4	30 Apr	74	F	-	III	-
H2	30 Apr	92	F	-	III	-
H1	30 Apr	101	F	-	II	-
H3	30 Apr	94	M	-	III	-
E4	4 May	114	F	-	VI/VII	-
E7	4 May	116	F	-	V	-
E3	4 May	136	F	-	VI/VII	-
E1	4 May	139	F	-	VI	-
E6	4 May	108	M	-	VI	-
E9	4 May	113	M	-	V	-
E8	4 May	115	M	-	V	-
E5	4 May	117	M	-	VI	-
E2	4 May	132	M	-	V	-
E10	4 May	133	M	-	V	-
I7	6 Jul	114	F	DEV	VII	0.31
I11	6 Jul	114	F	DEV	-	0.32
I6	6 Jul	115	F	DEV	-	0.19
I5	6 Jul	116	F	DEV	-	0.22
I3	6 Jul	116	F	DEV	-	0.23
I2	6 Jul	118	F	DEV	-	0.32
I8	6 Jul	119	F	DEV	-	0.31

[1] Maturity stage codes by examination method:

	Macroscopic	Histological
Immature	IMM	0,I
Developing	DEV	II,III,V,VI
Ripe	RIPE	VII
Ripe and Running	R&R	VIII
Spent	S	IX
Resting	REST	IV

[2] Not available.

Table 3. Continued

Sample ID	Date	Shell Height (mm)	Sex	Maturity Stages[1]		GSI
				Macro	Histo	
I1	6 Jul	121	F	DEV	-	0.28
I12	6 Jul	113	M	DEV	-	0.31
I4	6 Jul	115	M	DEV	-	0.36
I10	6 Jul	117	M	DEV	-	0.18
I9	6 Jul	118	M	DEV	VI	0.24
N5	7 Jul	109	F	DEV	VII	0.22
N6	7 Jul	128	F	DEV/RIPE	-	0.27
N4	7 Jul	100	M	DEV	-	0.26
N7	7 Jul	100	M	DEV	VI	0.30
N2	7 Jul	107	M	DEV	-	0.26
N1	7 Jul	109	M	DEV	-	0.22
N3	7 Jul	109	M	DEV	-	0.19
J13	18 Jul	75	F	DEV	V	0.27
J12	18 Jul	86	F	DEV	-	0.32
J10	18 Jul	86	F	DEV	-	0.37
J11	18 Jul	92	F	DEV	-	0.40
J5	18 Jul	92	F	DEV	-	0.35
J1	18 Jul	92	F	DEV	-	0.43
J4	18 Jul	95	F	DEV	VII	0.25
J6	18 Jul	100	F	DEV	-	0.38
J7	18 Jul	100	F	DEV	-	0.35
J2	18 Jul	103	F	DEV	-	0.29
J8	18 Jul	80	M	DEV	-	0.08
J3	18 Jul	93	M	DEV	-	0.36
J9	18 Jul	95	M	DEV	-	0.39
K12	21 Jul	81	F	DEV	-	0.38
K5	21 Jul	89	F	DEV	-	0.46
K1	21 Jul	89	F	DEV	VII	0.28
K9	21 Jul	89	F	DEV	VII	0.47
K8	21 Jul	93	F	DEV	-	0.41
K10	21 Jul	94	F	DEV	-	0.30
K4	21 Jul	81	M	DEV	-	0.39
K7	21 Jul	81	M	DEV	-	0.33
K6	21 Jul	86	M	DEV	VI	0.24
K3	21 Jul	92	M	DEV	-	0.22
K11	21 Jul	101	M	DEV	-	0.38
K2	21 Jul	105	M	DEV	VI	0.27
L3	22 Jul	100	F	DEV	-	0.39
L16	22 Jul	108	F	DEV	-	0.53
L2	22 Jul	110	F	DEV	-	0.24
L7	22 Jul	113	F	DEV	-	0.18
L10	22 Jul	113	F	DEV	-	0.41
L11	22 Jul	116	F	DEV	VII	0.41
L13	22 Jul	96	M	DEV	-	0.38
L6	22 Jul	97	M	DEV	-	0.46
L15	22 Jul	103	M	DEV	-	0.30
L1	22 Jul	105	M	DEV	-	0.31
L5	22 Jul	110	M	DEV	-	0.35
L14	22 Jul	112	M	DEV	-	0.35
L4	22 Jul	115	M	DEV	-	0.36
L9	22 Jul	119	M	DEV	VI	0.25
L8	22 Jul	127	M	DEV	-	0.28
L12	22 Jul	138	M	DEV	-	0.44
M3	27 Jul	125	F	DEV	-	0.33
M1	27 Jul	125	F	DEV/RIPE	VII	0.17
M5	27 Jul	128	F	DEV	-	0.28

Table 3. Continued

Sample ID	Date	Shell Height (mm)	Sex	Maturity Stages[1]		GSI
				Macro	Histo	
M4	27 Jul	134	F	DEV	-	0.30
M2	27 Jul	140	F	DEV/RIPE	-	0.19
M6	27 Jul	122	M	DEV	VII	0.22
O5	2 Aug	112	F	DEV	-	0.25
O10	2 Aug	113	F	DEV	-	0.40
O4	2 Aug	115	F	DEV	-	0.34
O9	2 Aug	116	F	DEV	-	0.40
O13	2 Aug	117	F	DEV	-	0.49
O15	2 Aug	118	F	DEV	VII	0.35
O17	2 Aug	119	F	DEV	-	0.27
O16	2 Aug	120	F	DEV	-	0.29
O11	2 Aug	127	F	DEV	-	0.40
O6	2 Aug	105	M	DEV	-	0.29
O1	2 Aug	111	M	DEV	-	0.28
O3	2 Aug	112	M	DEV	-	0.30
O14	2 Aug	113	M	DEV	-	0.29
O12	2 Aug	116	M	DEV	-	0.26
O2	2 Aug	118	M	DEV	-	0.40
O7	2 Aug	122	M	DEV	VI	0.35
O8	2 Aug	123	M	DEV	-	0.32
P12	10 Aug	89	F	DEV	VII	0.33
P10	10 Aug	92	F	DEV	-	0.34
P11	10 Aug	94	F	DEV	-	0.40
P9	10 Aug	103	F	DEV	-	0.40
P8	10 Aug	110	F	DEV	-	0.48
P1	10 Aug	110	F	DEV	-	0.34
Q1	10 Aug	110	F	DEV/RIPE	VII	0.42
Q8	10 Aug	110	F	DEV/RIPE	-	0.25
Q3	10 Aug	111	F	DEV/RIPE	-	0.42
Q9	10 Aug	112	F	DEV/RIPE	-	0.42
Q5	10 Aug	112	F	DEV/RIPE	-	0.41
P2	10 Aug	116	F	DEV	-	0.33
Q14	10 Aug	87	M	DEV	VII	0.41
Q12	10 Aug	103	M	DEV/RIPE	-	0.39
Q4	10 Aug	105	M	DEV/RIPE	-	0.34
Q13	10 Aug	105	M	DEV/RIPE	-	0.46
Q10	10 Aug	108	M	DEV/RIPE	-	0.48
P3	10 Aug	110	M	DEV	-	0.35
Q2	10 Aug	113	M	DEV/RIPE	-	0.35
P5	10 Aug	113	M	DEV	-	0.35
P7	10 Aug	115	M	DEV	-	0.47
Q11	10 Aug	117	M	DEV/RIPE	-	0.43
P4	10 Aug	118	M	DEV	VI	0.35
Q7	10 Aug	119	M	DEV/RIPE	-	0.35
P6	10 Aug	120	M	DEV	-	0.39
Q6	10 Aug	124	M	DEV/RIPE	-	0.45
R4	16 Aug	103	F	DEV/RIPE	VII	0.23
R3	16 Aug	108	F	DEV/RIPE	-	0.37
R15	16 Aug	109	F	DEV/RIPE	-	0.43
R19	16 Aug	112	F	DEV/RIPE	-	0.26
R10	16 Aug	112	F	DEV/RIPE	-	0.23
R13	16 Aug	114	F	DEV/RIPE	-	0.43
R11	16 Aug	115	F	DEV/RIPE	-	0.41
R20	16 Aug	117	F	DEV/RIPE	-	0.39
R9	16 Aug	134	F	DEV/RIPE	-	0.40
R7	16 Aug	142	F	DEV/RIPE	-	0.33
R17	16 Aug	106	M	DEV/RIPE	-	0.25

Table 3. Continued

Sample ID	Date	Shell Height (mm)	Sex	Maturity Stages[1]		GSI
				Macro	Histo	
R8	16 Aug	109	M	DEV/RIPE	-	0.39
R5	16 Aug	111	M	DEV/RIPE	VII	0.34
R2	16 Aug	113	M	DEV/RIPE	-	0.40
R12	16 Aug	114	M	DEV/RIPE	-	0.47
R6	16 Aug	114	M	DEV/RIPE	-	0.35
R14	16 Aug	117	M	DEV/RIPE	-	0.43
R21	16 Aug	117	M	DEV/RIPE	-	0.27
R16	16 Aug	118	M	DEV/RIPE	-	0.37
R18	16 Aug	118	M	DEV/RIPE	-	0.36
R1	16 Aug	118	M	DEV/RIPE	-	0.35

Table 4. Combinations of histological classifications of gonads used for comparison with macroscopic classifications

Macroscopic	Histological
Immature	0,I
Developing	II,III,V,VI
Ripe	VII
Ripe and Running	VIII
Spent	IX
Resting	IV

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