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Dungeness Crab Mating Study 1987/1988

by

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And

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Alaska Department of Fish and Game **Division of Commercial Fisheries**

Symbols and Abbreviations

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$log_{2,}$ etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

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UASE 87-20

DUNGENESS CRAB MATING STUDY

Dr. Thomas C. Shirley

Molly Sturdevant

ANNUAL REPORT

Alaska Department of Fish and Game

School of Fisheries and Science

UNIVERSITY OF ALASKA, JUNEAU

UASE 87-20

FINAL REPORT

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TITLE:	Dungeness Crab Mating Study
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Beginning Date:	September 7, 1987
Ending Date:	January 15, 1988

INTRODUCTION

Mating periods and size at maturity of the Dungeness crab, Cancer magister Dana, are poorly known in the Alaskan part of their range. The data are difficult to collect, as standard sampling techniques such as crab pots or trawling disturb mating or yield biased results (e.g., mating could occur after concentration of the crabs in pots or trawls). Only a few diver observations or incidental reports exist. Also, physiological maturity (the presence of mature gametes) is not always an indication of the crab's ability to successfully mate. Sexually mature male crabs as small as 137 mm carapace width (CW) have been reported from Washington, but the smallest male reported to be in a mating embrace was 152 mm CW (MacKay, 1942).

In the more southerly parts of their range, Dungeness males have been reported to mature as small as 110 mm CW, but significant breeding did not occur until they attained a CW of 140 mm (Butler, 1960). Female crabs have been reported to mature at approximately 100 mm CW (Weymouth and MacKay, 1936; Butler, 1960). All male crabs >100 mm CW from southeastern Alaska were found to have mature sperm in their reproductive tracts (Shirley et al., 1986), but the size at which they become reproductively active is unknown.

Dungeness crabs have been commercially harvested from Kodiak through southeastern Alaska since the early 1900's.

Fishing effort (number of vessels) has steadily increased, in most areas by 500% from the late 1960's to the early 1980's (Koeneman, 1985; Kimker, 1985,; Merritt, 1985; Eaton, 1985). In 1984-85, Alaska contributed 34% of all Dungeness crabs caught along the western U.S. and British Columbia coastline, a significant decline from the previous year's catch (Matsen, 1986).

One goal of management has been to maintain the stability of the Dungeness crab stock in Alaska. Management policies have included restrictions on size, sex and season and have required escape rings and limited mesh sizes on commercial crab pots. Of particular concern in recent years has been the protection of crabs during vulnerable parts of their life cycle. A mid-season (August - October) closure in the commercial fishery in southeastern Alaska in recent years has intended to shelter crabs during times of mating activities and female molting, assumed to be critical life history periods (Shirley and Shirley, 1988).

Large concentrations of mating pairs of Dungeness crabs have been observed in the shallow waters of southeastern Alaska during the fall months (T. Shirley, unpublished observations). The intent of this study was to determine the size of reproductive activity of Dungeness crabs in southeastern Alaska and to determine the size relationship between male and female mating pairs. Incidental data such as population density and size-frequency distributions of the population were also collected.

METHODS

Dungeness crabs were collected by hand in Bridget Cove (Figure 1), approximately 50 km N of Juneau on 12 evenings during spring low tides from September through November, 1987. Carapace widths of both male and female crabs were measured with Vernier calipers. The carapaces of all crabs that were collected were numbered with short-term tags (waterproof markers) to prevent repeat collection and to identify those which were returned to the lab. Temperature and salinity of the intertidal water, tidal stage and weather conditions (wind, wave height, precipitation, water clarity) were recorded on collection dates (Appendix A). Density estimates of the crab population were attempted by counting all crabs observed within seven 9.0 m^2 quadrats within the cove.

Mating pairs were numbered to permit information retrieval about the mates; 59 mating pairs were returned to the lab. Mating pairs were maintained together in flow-through seawater tanks (Living Streams) until several days after the females had molted and mating had occurred. The sexes were then separated. All male crabs were necropsied on October 22; their total wet weight was recorded and samples of their gonads were preserved in Bouin's fixative for possible histological analysis. Female crabs were maintained in the lab and fed a mixed diet of fish and bivalves until January,

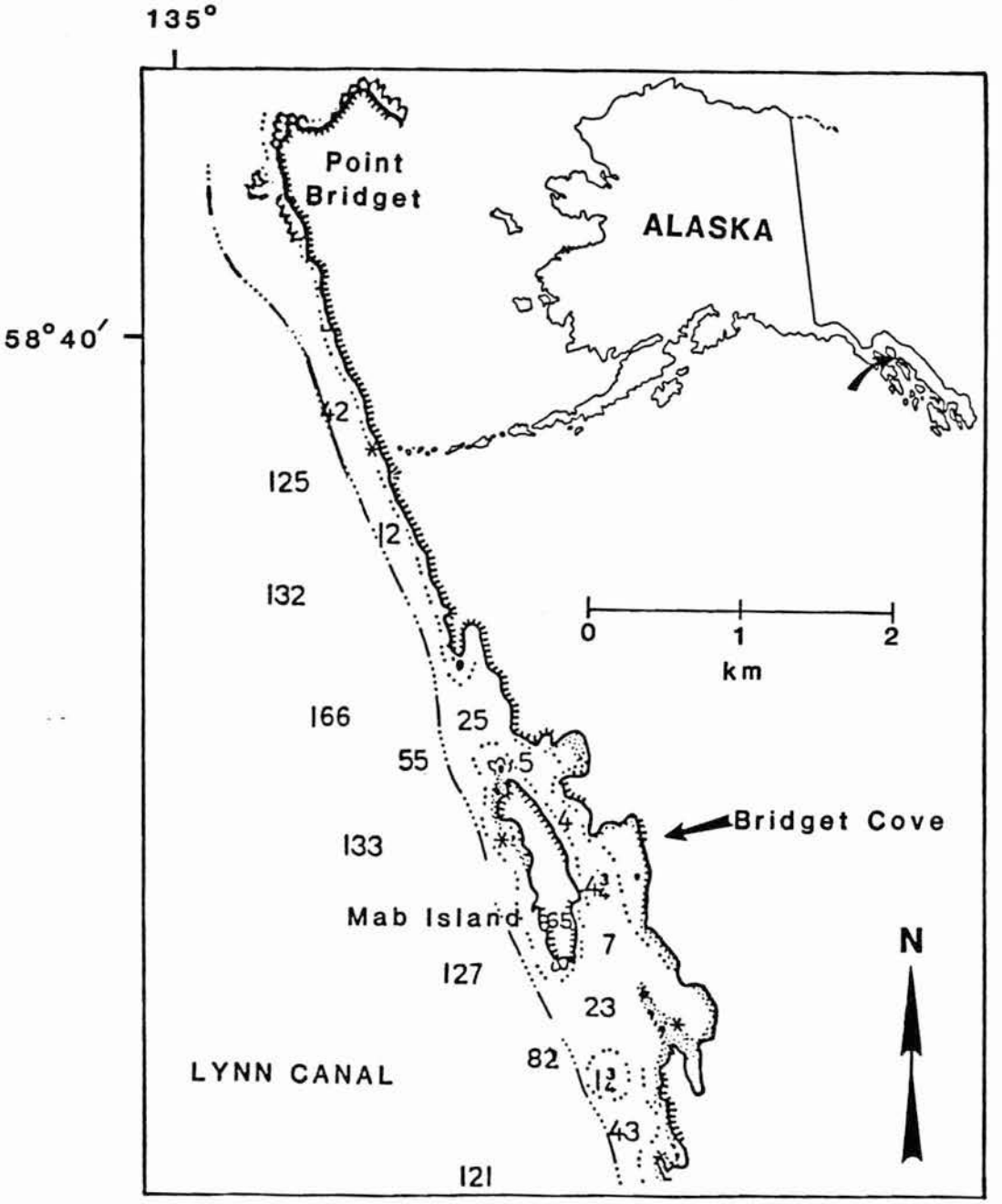

Figure 1. Map of Bridget Cove, Alaska. Depths listed are in fathoms.

1988. At that time all but 15 of the females were necropsied. The total wet weight of the female crabs and wet weight of their gonads were measured. The presence of spermatophores and the color and condition of the ovary was recorded.

For the females maintained in the lab, the premolt and postmolt carapace widths were measured. Carapace widths were recorded two days after molting. Carapace hardness of a random subset of 10 of the females was monitored with a durometer (Pacific Transducer Corporation modified model 307LCRB4) until the experiment was terminated. Hardness measurements were made at a standardized carapace location, on the right ventral side between the cheliped and first periopod, using a technique developed by Alaska Department of Fish and Game personnel (Dave Hicks, ADF&G, personal communication).

RESULTS AND DISCUSSION

A total of 109 pairs of mated Dungeness crabs were collected on 12 different dates between September 24 and November 4, 1987 (Table 1). Mated female crabs ranged in CW from 79.8 mm to 116.5 mm, while mated males ranged in size from 121.0 mm to 176.8 mm CW. No significant relationship was present between the sizes of the mated pairs, however male crabs were always larger than their mate (Figure 2). Mating pairs were present in the field on the first (September 24) and last date (November 4) that observations were made.

Table 1. Carapace widths of male and female pairs collected in the field, from dungeness crab mating study, Bridget Cove, 1987. Soft females (postmolts) removed from data (FNo 10, 13, 47, 53, 55, 59, 62 did not molt in the lab). Abbreviations: Date = date collected (month day year), FNo = Female Number, FCW = Female Carapace Width, MNo = Male Number, MCW = Male Carapace Width.

Date	FNo	FCW	MNo	MCW
92487	1	101.2	1001	136.1
92587	2	94.5	1002	138.0
92587	3	87.8	1003	141.2
92587	4	89.5	1004	134.4
92587	5	87.5	1005	167.2
92587	6	97.0	1006	152.2
92587	7	89.2	1007	150.7
92687	8	91.5	1008	133.2
92687	9	93.0	1009	131.1
92687	11	80.0	1011	144.2
92687	12	87.6	1012	132.0
92687	14	91.4	1014	142.3
92687	16	98.1	1016	139.8
92687	17	97.4	1017	139.1
92687	18	92.3	1018	140.4
100676	19	93.7	1019	151.2
100676	20	100.0	1020	145.5
100676	21	91.6	1021	151.6
100676	22	87.4	1022	146.8
100687	23	98.3	1023	160.8
100687	24	90.2	1024	132.4
100687	25	91.8	1025	149.2
100676	26	87.0	1026	138.3
100787	27	94.3	1027	137.5
100787	28	95.9	1028	148.1
100787	29	93.6	1029	140.8
100787	30	81.9	1030	151.8
100787	31	95.5	1031	138.0
100787	32	92.8	1032	170.4
100787	33	91.7	1033	155.5
100787	34	92.1	1034	146.0
100787	35	98.0	1035	152.8
100787	36	95.1	1036	154.9
100787	37	90.2	1037	134.0
100787	38	79.8	1038	139.2
100787	39	103.5	1039	166.2
100787	40	80.8	1040	151.1
100787	41	96.2	1041	136.8
100787	42	99.4	1042	169.8
100787	43	96.3	1043	148.2
100787	44	94.6	1044	140.9
100887	45	96.2	1045	142.0
100787	46	112.1	1046	167.8
100887	48	86.3	1048	154.8
100887	49	101.7	1049	142.8

Table 1, continued.

100887	50	87.8	1050	147.8
100887	51	90.5	1051	144.3
100887	52	102.0	1052	134.9
100887	53	89.7	1053	137.3
100887	54	86.2	1054	130.9
100887	55	100.5	1055	159.1
100887	56	88.2	1056	135.1
100887	57	96.2	1057	134.8
100887	58	86.1	1058	145.1
100887	60	99.4	1060	135.7
100887	61	90.9	1061	137.1
100987	63	82.5	1063	151.1
100987	64	101.7	1064	146.2
100987	65	97.5	1065	130.0
100987	66	98.5	1066	121.9
100987	67	80.9	1067	161.2
100987	71	102.8	1071	163.4
100987	72	89.3	1072	153.4
100987	73	100.3	1073	144.1
100987	74	92.6	1074	159.4
100987	75	100.7	1075	161.5
100987	76	99.0	1076	149.7
100987	77	94.2	1077	149.4
100987	78	82.2	1078	151.0
102287	79	83.2	1079	145.8
102287	80	80.0	1080	123.8
102287	81	102.0	1081	163.9
102287	82	84.3	1082	125.6
102287	83	96.1	1083	121.0
102287	84	92.3	1084	147.3
102287	85	90.3	1085	147.8
102487	87	116.5	1087	176.8
102587	89	99.1	1089	152.3
102587	90	87.5	1090	145.6
102587	91	98.1	1091	136.5
102587	92	104.2	1092	154.6
102587	93	93.3	1093	157.3
110387	95	91.7	1095	133.8
110487	96	99.6	1096	133.7
110487	97	93.7	1097	167.2
110487	98	98.7	1098	145.3
110487	99	96.8	1099	154.0
110487	100	90.6	1100	147.1
110487	101	99.7	1101	149.1
110487	102	101.4	1102	150.3
110487	103	97.4	1103	143.6
110487	104	92.2	1104	136.4
110487	105	91.8	1105	149.4
110487	106	89.0	1106	143.0
110487	107	100.5	1107	150.1
110487	108	93.4	1108	135.3
110487	109	97.0	1109	146.5

Large female Dungeness crabs were not observed in the shallow waters of Bridget Cove, even though large (legal-sized) male crabs were. Of the 172 female crabs measured during the study (includes 63 non-mated females, see below), none were ovigerous; likewise, no ovigerous female crabs were observed during the study and no females extruded eggs while being maintained in the lab. All sizes of females that were collected, however, were observed in mating embraces with male crabs of 120 mm CW or larger.

Nearly all mated female crabs that were returned to the lab molted within a few days (53% within three days, 83% within a week). The average increase in size with molting was 23.5%. The smaller crabs had molt increments as high as 30.8%; the larger crabs had increments as small as 16.9%. The molt increments measured in this study are very similar to those calculated from average instar sizes of male Dungeness crabs by Poole (1967), Cleaver (1949) and Butler (1961) and from individual male and female crabs by Koeneman (1985) and Kondzela and Shirley (1988).

No female crabs had extruded eggs by January, 1988 and all but 15 were necropsied. Spermatophores were found within the genital tracts of nearly all mated females. The gonads had begun to develop in most of the females by the time of necropsy, comprising an average of 3.2% (range of 0.5 - 4.8%) of the total wet weight of the crabs.

A significant relationship existed between carapace hardness and number of days postmolt (Figure 3). The

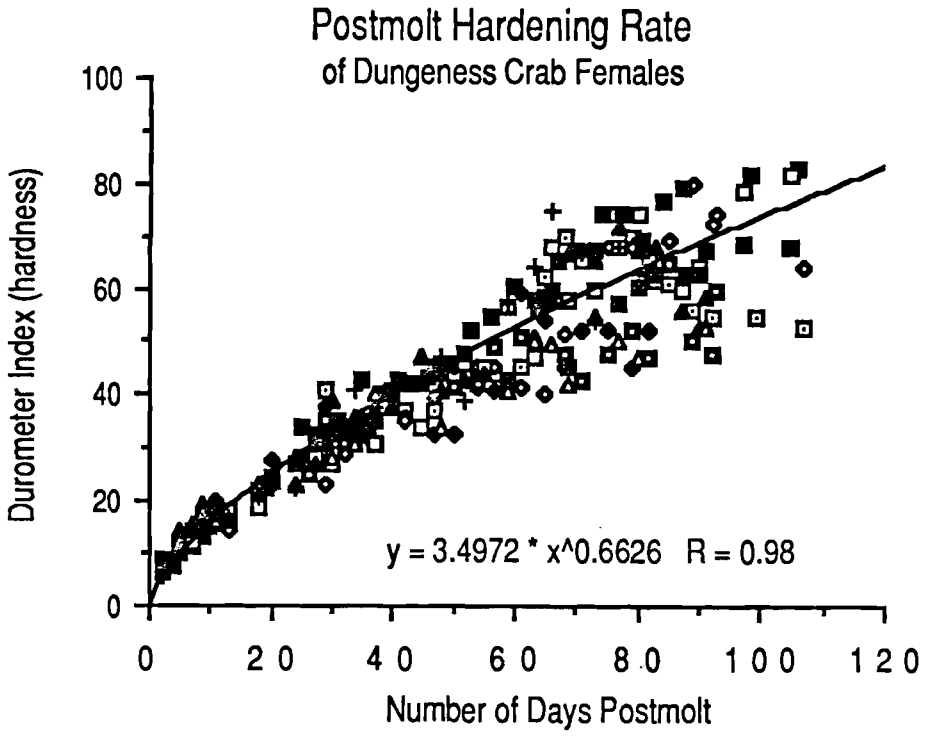

Figure 3. Increase in carapace hardness after molting for female Dungeness crabs from Bridget Cove.

carapaces of the female Dungeness crabs continued to harden at a uniform rate until approximately 60 days postmolt, at which time no mean increase in hardness was evident (Table 2).

An additional 106 non-mating crabs were collected and measured, yielding a total of 172 female crabs and 150 male crabs that were measured from Bridget Cove during the study (Table 3). The size distribution of female crabs was distinctly smaller (CW range of 75 - 135 mm) than that of the male crabs (CW range = 100 - 177 mm) (Figure 4). The size-frequency distribution of the females was essentially bimodal (Figure 5), while that of the males was polymodal (Figure 6). The smallest males collected during the study (100 - 120 mm) did not participate in mating activities. In contrast, the smallest females collected were found in mating activities.

Table 2. Female Dungeness crab carapace hardeness over time. Hardness was measured with a durometer, between the basal joints of first and second appendages on the left side of the body. Hardness scale is from 0-100. Abbreviations: CN = crab number; MTD = date of molt; "1014" = Oct. 14, 1987; "114" = Jan. 14, 1988; MSD = date of measurement; S = sacrificed; MT = mortality.

CN	27	52	54	57	58	60	45	49	34	19
MTD	1014	1014	1014	1014	1014	1013	1012	1012	1012	1012
MSD										
1016	6.5	6.0	8.5	5.5	8.5	7.5	8.5	9.0	7.5	7.5
1019	12.0	14.5	12.5	10.5	10.0	13.0	11.5	13.5	12.0	11.5
1021	12.0	15.5	14.5	14.5	14.5	14.0	13.5	16.0	17.0	13.0
1023	14.5	19.5	18.0	16.5	15.0	15.0	18.0	20.0	17.0	18.0
1025	16.0	17.5	16.5	17.5	18.0	16.5	18.0	16.5	16.5	14.5
1102	19.0	22.0	23.0	20.5	22.0	22.5	24.5	27.5	24.0	23.0
1108	27.0	28.0	23.0	22.5	27.0	34.0	26.0	28.0	25.0	27.0
1111	28.0	31.0	27.0	27.0	31.0	33.0	34.0	30.0	33.0	23.0
1114	27.0	39.0	28.0	30.5	33.0	35.0	32.0	32.0	31.0	29.0
1118	32.0	36.0	31.0	41.0	33.0	43.0	34.0	32.0	35.0	34.0
1121	31.0	37.0	40.0	38.0	35.0	40.0	41.0	32.0	35.0	37.5
1124	40.0	38.0	--	39.0	41.0	43.0	37.0	36.0	42.0	35.0
1129	34.0	47.0	--	42.0	42.0	43.5	37.0	33.0	45.0	39.5
1202	--	41.0	34.0	47.0	44.0	46.0	44.0	33.0	41.5	45.5
1206	46.0	43.0	--	39.0	48.0	52.0	43.0	41.5	42.0	45.0
1209	45.5	44.0	--	--	--	55.0	44.0	41.0	49.0	41.5
1213	56.5	42.0	41.0	57.5	43.0	60.5	45.0	59.0	51.0	40.5
1217	47.0	51.0	50.0	64.0	58.0	56.0	62.0	54.0	58.5	51.5
1220	68.0	58.0	49.5	75.0	60.0	65.5	70.0	45.0	48.0	67.0
1223	58.0	66.5	42.0	--	45.0	67.0	65.5	52.5	42.5	68.0
1227	60.0	65.5	55.0	54.0	67.0	74.0	74.0	52.0	47.5	68.0
1231	68.0	71.5	50.0	68.0	57.5	74.0	70.0	45.0	52.0	63.0
103	74.0	67.0	47.0	63.0	60.5	69.0	66.0	52.0	47.0	69.0
106	61.5	68.0	--	--	63.0	77.0	61.0	MT	65.0	80.0
110	60.0	56.0	--	--	79.0	63.0	56.0	--	50.0	72.5
113	64.0	53.0	--	--	63.0	67.0	55.0	--	48.0	74.0
114	--	58.5	53.0	66.0	--	--	--	--	60.0	--
121	78.5	S	S	S	68.5	82.0	55.0	--	S	64.0
129	82.0	--	--	--	68.0	83.0	53.0	--	--	54.0

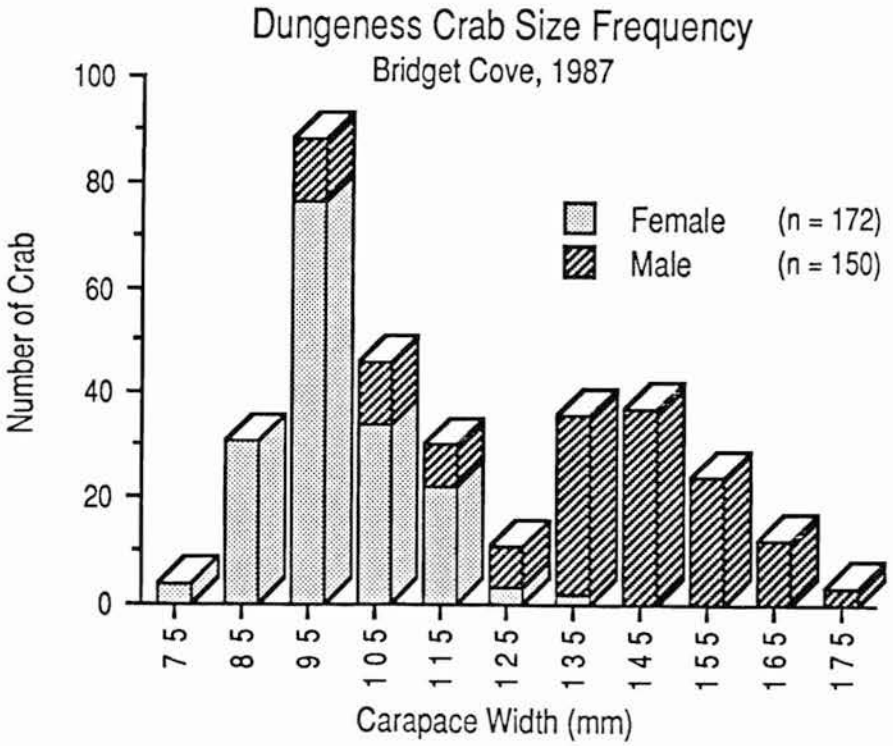

Figure 4. Size-frequency distribution of Dungeness crabs collected in Bridget Cove.

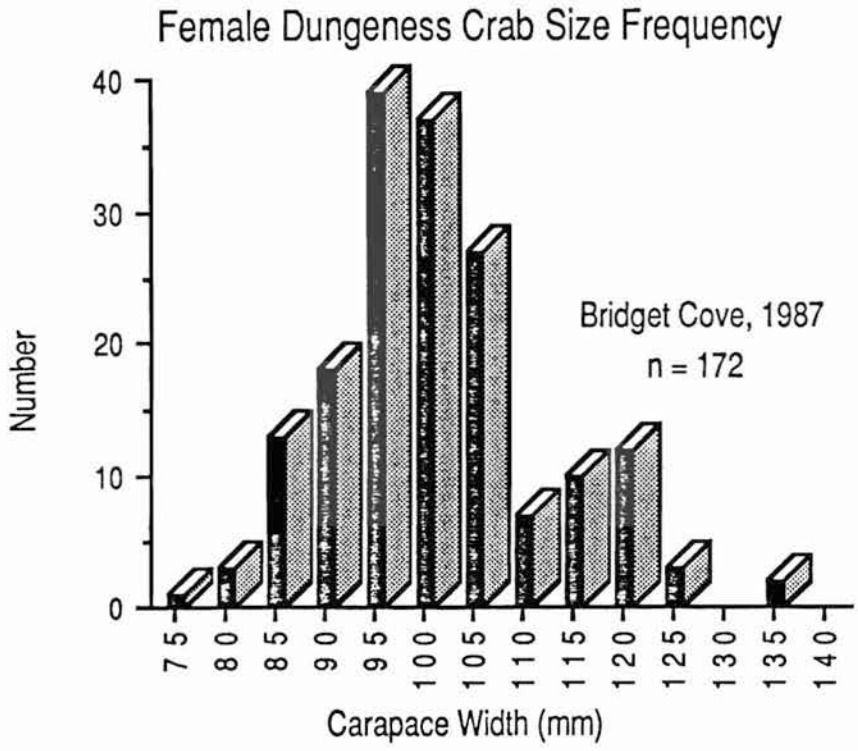

Figure 5. Size-frequency distribution of female Dungeness crabs collected in Bridget Cove.

Table 3. Male and female Dungeness crabs randomly encountered at Bridget Cove, fall, 1987. Abbreviations: CN = crab number, Date = date collected, CW = carapace width (mm), 1 = female, 2 = male, S = soft postmolt.

CN	Date	CW	Sex
2001	92487	113.3	1
2002	92487	86.7	1
2003	92487	97.2	1
2004	92487	137.6	2
2005	92487	98.9	2
2006	92487	103.3	2
2007	92487	123.7	1S
2008	92487	98.7	2
2009	92487	104.7	2
2010	92487	105.2	2
2011	92487	107.3	1
2012	92487	103.7	2
2013	92487	108.3	2
2014	92487	117.7	2
2015	92487	111.2	2
2016	92487	104.2	2
2017	92487	95.9	2
2018	92487	110.2	2
2019	92487	89.7	2
2020	92487	83.0	2
2021	92487	112.2	2
2022	92487	117.9	2
2023	92487	116.3	2
2024	92487	99.0	2
2025	92487	125.6	1S
2026	92487	138.7	2
2027	92487	100.9	2
2028	92487	98.4	1
2029	92487	95.1	2
2030	92487	88.2	?
2031	92487	84.1	2
2032	92487	92.1	2
2033	92487	99.5	2
2034	92487	100.6	1
2035	92487	104.2	2
2036	92487	91.3	2
2037	92487	101.7	2
2038	92487	102.9	1
2039	92487	106.5	1
2040	92487	108.2	1
2041	92487	117.1	1
2042	92487	107.2	2
2043	92487	107.7	2
2044	92487	97.3	2
2045	92487	105.3	2
2046	92587	80.8	2
2047	92587	112.3	1
2048	92587	105.0	1

Table 3. continued.

2049	92587	138.4	1
2050	92587	104.1	1
2051	92587	106.3	1
2052	92587	101.0	2
2053	92587	95.4	2
2054	92587	80.4	1
2055	92587	104.0	1
2056	92587	92.7	1
2057	92587	129.7	1
2058	92587	72.6	2
2059	92587	115.0	2
2060	92587	100.0	2
2061	92587	98.5	2
2062	92587	114.0	2S
2063	92587	83.3	1
2064	92587	91.7	2S
2065	92587	100.1	2
2066	92587	119.2	1
2067	92587	108.6	1
2068	92587	93.5	2
2069	92587	91.6	2
2070	92587	147.0	1
2071	92587	83.4	2
2072	92587	103.5	2
2073	92587	115.8	2
2074	92587	111.7	1
2075	92587	97.5	1
2076	92587	107.7	1
2077	92587	100.1	2
2078	92587	112.0	2
2079	92587	111.0	1
2080	92587	79.1	1
2081	92587	85.6	2
2082	92587	91.7	2
2083	92587	112.4	1
2084	92587	93.2	2
2085	92587	89.0	1
2086	92587	84.2	1
2087	92587	94.8	2
2088	92587	106.8	1
2089	92587	123.2	2S
2090	92587	95.0	1
2091	92587	115.1	2
2092	92587	106.8	2
2093	92587	108.0	2
2095	92587	123.0	1S
2096	92587	144.4	1
2097	92587	130.4	1S
2098	92587	101.9	2
2099	92587	113.0	1
2100	92587	113.5	2S
2101	92587	121.0	2S

Table 3. continued.

2102	92587	93.3	2
2103	92587	94.6	1
2104	92587	77.2	2
2105	92587	98.2	2S
2106	92587	75.1	2

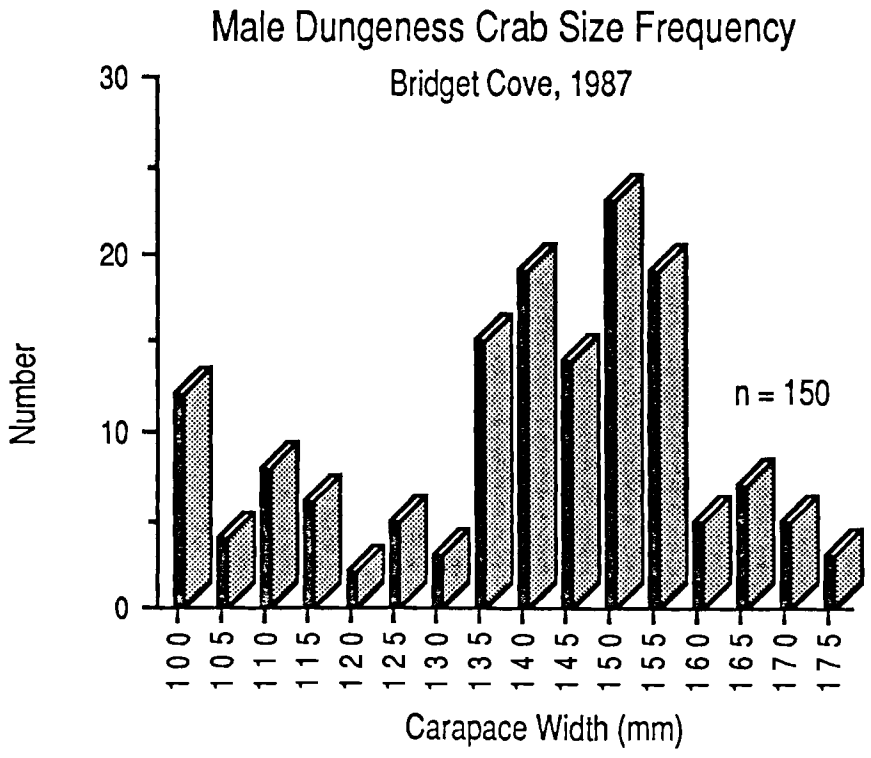

Figure 6. Size-frequency distribution of male Dungeness crabs collected in Bridget Cove.

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Appendix A. Meteorological and hydrographical data recorded at Bridget Cove on collection days during fall, 1987. Temp=water temperature; Sal=salinity in ppt; Time=time at start of collection, Tide=tidal height in feet.

Date	Time	Temp	Sal	Tide	Comments
9/24	2048	9.5	19	-0.9	overcast, occasional rain, breeze
9/25	2120	9.0	7	-1.0	overcast, occasional rain
9/26	2157	9.5	21	-0.8	clear, 5-10 knots, murky
10/6	1927	8.8	25	-1.9	partly clear, dry, calm
10/7	2007	8.8	23	-2.7	clear, cold, breeze
10/8	2046	7.6	-	-2.8	high overcast, N breeze
10/9	2124	8.6	25	-2.3	overcast, brisk breeze
10/22	1948	7.0	24	-1.5	rain, windy, waves murky
10/23	2023	-	-	-2.1	40 knots, rain, murky
10/24	2101	7.0	25	-2.2	10-20 knots, rain, murky
10/25	2041	-	-	-1.8	gusty, partly clear, dry
10/26	2129	-	-	-1.0	20-30 knots, no sampling
11/3	1730	6.5	28	-1.1	gusts, waves, few crabs
11/4	1809	6.5	25	-2.2	clear, calm, full moon
11/20	1826	-	-	-2.1	SE 25 knots, murky runoff, no sampling

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