

AN ABSTRACT OF THE THESIS OF

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(Name) (Degree)
in FISHERIES presented on Dec. 21, 1973
(Major) (Date)

Title: DISTRIBUTION AND REPRODUCTIVE BIOLOGY OF
CRANGON FRANCISCORUM (STIMPSON) AND CRANGON
NIGRICAUDA (STIMPSON), IN YAQUINA BAY, OREGON

Abstract approved: Redacted for privacy
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The distribution, reproduction, and growth of Crangon nigricauda (C. n.) and C. franciscorum (C. f.) in Yaquina Bay, Oregon are described. The study is based on examination of 8,244 C. n. and 4,568 C. f. collected by beam trawl at bimonthly intervals from December 1970 to February 1972. Basic meristics and catch data are also presented on sympatric species of shrimp.

The distribution of C. n. and C. f. is generally related to water temperature and salinity. Both species exhibit a wide tolerance for temperature (5.2-16.5 C for C. n.; 5.3-21.5 C for C. f.) and salinity (≥ 19 ppt for C. n.; 0.2-34.4 ppt for C. f.). Between species, C. nigricauda display a preference for cooler temperature and more saline water than did C. franciscorum. Within species, variations in the response to temperature and salinity changes were observed between size and sex groupings.

The spawning season for both species is from December to mid-August, and ovigerous females disappear from the bay in September (C. n.) and August (C. f.). Berried females were collected in waters ranging from 6.8-12.9 C (C. n.) and 6.8-19.2 C (C. f.), and with salinity of ≥ 25.4 ppt (C. n.) to 14.6-34.4 ppt (C. f.). Both species exhibit bimodal spawning periods with larger females initiating the spawning season. The relevance of such large females is noted in the reproductive potential where egg carrying capacity is a factor of length. The largest ovigerous females carry from 7,000 eggs (C. n.) to 4,764 eggs (C. f.) and the smallest carry from 2,393 (C. n.) to 1,923 (C. f.).

Growth of young was defined by the regression equations:
 $Y = -6.04 + 0.76 (X)$ summer and $Y = +7.79 + 0.95 (X)$ winter for C. n. Only a summer growth rate estimate was attainable for C. franciscorum: $Y = -25.44 + 1.37 (X)$. Both species exhibited differential growth after attaining sexually recognizable sizes, with females being 8-10 mm TL larger than males at maturity. Females were believed to live a maximum of 1-1/2 yrs. and males not more than 1 yr.

Distribution and Reproductive Biology of
Crangon franciscorum (Stimpson) and
Crangon nigricauda (Stimpson),
in Yaquina Bay, Oregon

by

Earl Eldon Krygier

A THESIS

submitted to

Oregon State University

in partial fulfillment of
the requirements for the
degree of

Master of Science

June 1974

APPROVED:

Redacted for privacy

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Date thesis is presented Dec. 21, 1973

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TABLE OF CONTENTS

	<u>Page</u>
INTRODUCTION	1
METHODS AND MATERIALS	4
RESULTS	13
Distribution	13
<u>C. nigricauda</u>	13
<u>C. franciscorum</u>	22
Reproduction	29
<u>C. nigricauda</u>	29
<u>C. franciscorum</u>	33
Growth	39
<u>C. nigricauda</u>	39
<u>C. franciscorum</u>	41
DISCUSSION	44
LITERATURE CITED	55
APPENDIX	58

LIST OF FIGURES

<u>Figure</u>		<u>Page</u>
1	Map of Yaquina Bay, Oregon, showing the four sampling stations where Crangonid shrimp were collected.	5
2	Beam trawl, with attached 1-m wheel, used to sample Crangonid shrimp in Yaquina Bay, Oregon.	5
3	Stages of egg development for <u>Crangon nigricauda</u> and <u>C. franciscorum</u> showing (A) egg spherical, yolk uniform, (B) egg oblong, larval hemisphere distinct from yolk, (C) eye pigment visible, (D) egg near hatching with large eyes and abdomen free of head.	10
4	Temperature and salinity values by date of collection at four <u>Crangon</u> sampling stations in Yaquina Bay, Oregon, 1970-72.	15
5	Relative abundance and date of collection of sexually immature <u>Crangon nigricauda</u> from three sampling stations in Yaquina Bay, Oregon, 1970-72.	16
6	Relative abundance and date of collection of sexually mature <u>Crangon nigricauda</u> from three sampling stations in Yaquina Bay, Oregon, 1970-72.	17
7	Length-frequency histograms of sexually unrecognizable and sexually recognizable <u>Crangon nigricauda</u> in Yaquina Bay, Oregon, 1971-72.	23
8	Relative abundance and date of collection of sexually immature <u>Crangon franciscorum</u> from four sampling stations in Yaquina Bay, Oregon, 1970-72.	27

<u>Figure</u>		<u>Page</u>
9	Relative abundance and date of collection of sexually mature <u>Crangon franciscorum</u> from four sampling stations in Yaquina Bay, Oregon, 1970-72.	28
10	Photomicrograph of a sperm of <u>Crangon nigricauda</u> taken during the 1972 spawning season in Yaquina Bay.	30
11	Length-frequency histograms of sexually unrecognizable and sexually recognizable <u>Crangon franciscorum</u> in Yaquina Bay, Oregon, 1970-72.	34

LIST OF TABLES

<u>Table</u>		<u>Page</u>
1	Slope and R^2 values describing the relationship of temperature to size and abundance of each age and sex group of <u>Crangon nigricauda</u> and <u>C. franciscorum</u> in Yaquina Bay.	14
2	Capture point, date of collection, and stage of egg development for ovigerous <u>Crangon nigricauda</u> from Yaquina Bay, Oregon.	18
3	Slope and R^2 values describing the relationship of salinity to size and abundance of each age and sex group of <u>Crangon nigricauda</u> and <u>C. franciscorum</u> in Yaquina Bay.	19
4	New slope and R^2 values describing the relationship of the temperature-salinity interaction to size and abundance of each age and sex group of <u>Crangon nigricauda</u> and <u>C. franciscorum</u> from Yaquina Bay.	21
5	Frequency, location and date of capture of small and large ovigerous <u>Crangon nigricauda</u> collected in Yaquina Bay.	32
6	Capture point, date of collection, and stage of egg development of ovigerous <u>Crangon franciscorum</u> collected in Yaquina Bay.	36
7	Data showing the frequency, location and date of capture of small and large ovigerous <u>Crangon franciscorum</u> in Yaquina Bay, and the percent of mature females bearing eggs.	37

LIST OF APPENDIX TABLES

<u>Table</u>		<u>Page</u>
1	Basic meristic information and date and location of capture of <u>Pandalus danae</u> (Stimpson) in Yaquina Bay, Oregon, 1970-72.	58
2	Basic meristic information and date and location of capture of <u>Pandalus platyceros</u> (Brandt) in Yaquina Bay, Oregon, 1970-72.	64
3	Basic meristic information and date and location of capture of <u>Heptacarpus brevirostris</u> (Dana) in Yaquina Bay, Oregon, 1970-72.	65
4	Basic meristic information and date and location of capture of <u>Heptacarpus sitchensis</u> (Brandt) in Yaquina Bay, Oregon, 1970-72.	69
5	Length, sex, condition of females, and date of capture of <u>Crangon nigricauda</u> from three locations off Moolack Beach, Oregon, 1973.	75
6	Date, location of capture, and length of female <u>Crangon franciscorum</u> infected by the isopod <u>Argeia pugettensis</u> in Yaquina Bay, Oregon, 1970-72.	76

DISTRIBUTION AND REPRODUCTIVE BIOLOGY OF CRANGON
FRANCISCORUM (STIMPSON) AND CRANGON
NIGRICAUDA (STIMPSON), IN
YAQUINA BAY, OREGON

INTRODUCTION

This thesis reports on a biological study of Crangonid shrimp (formerly Cragonid [Holthuis 1951]) in Yaquina Bay, Oregon. The investigation was based on analysis of samples collected biweekly from December 1970 through February 1972. The species studied, Crangon nigricauda (Stimpson) and Crangon franciscorum (Stimpson), comprise the major portion of epifaunal decapod shrimp in Yaquina Bay. Crangonids are important in estuaries because they often predominate in the diet of sport and marketable fishes (Herdman 1904; Meredith 1952; Daiber 1959; Allen 1960; Hess 1961; Haertel and Osterberg 1966; Makarov 1966). The agitation of bottom sediments in the shrimp's search for food and protection, and the frequency of molts (Lloyd and Yonge 1947) contribute to the cycling of nutrients. Because of their ecological importance, this study was conducted to provide new knowledge on distribution, reproduction, and growth of these shrimp in Yaquina Bay. In addition, meristic data on sympatric species of shrimp are supplied in the Appendix.

Several investigations have been conducted on the distribution and biology of Crangonids outside of Oregon. Rathbun (1904) reported

that C. nigricauda is distributed from Comox, British Columbia to Lower California at depths ranging from 3-31 f; and that C. franciscorum is distributed from southeastern Alaska to San Diego, California at depths ranging from about 1-29 f. Schmitt (1921) reported that C. nigricauda may occur as far north as Alaska and as far west as Japan.

Isreal (1936) discussed aspects of the life history of both species in San Francisco Bay, California, and supplied data on their reproductive biology and growth. The history of the fishery on these species in San Francisco Bay was discussed by Bonnot (1932). Haertel and Osterberg (1966), in their study of the lower Columbia River, noted the distribution of C. franciscorum within the estuary and provided information on their place in the food web.

Much information on these shrimp was interpreted from studies conducted on other species. Allen (1960; 1966) discussed the migration, reproductive biology, growth, and feeding habits of Crangon allmani and C. vulgaris in Northumberland waters of England. Meredith (1952) described development of the ovary and ovum as well as morphological changes in the reproductive cycle of both sexes for C. vulgaris. She also described growth, size distribution, and migration of the species in the Liverpool Bay area. Other aspects of the biology of C. vulgaris were studied in Bristol Channel and Severn Estuary by Lloyd and Yonge (1947). Price (1962) defined

growth rates, reproductive potential, and food habits of C.
septemspinosa in the Delaware Bay region. The larval forms of
several species of Crangonids were described by Lebour (1931),
Needler (1941), and Loveland (1968).

METHODS AND MATERIALS

Crangonids were captured at four sampling stations in Yaquina Bay (Fig. 1) by use of a 63-in. wide by 22-in. high beam trawl (Fig. 2). The sampling sites represent different habitat types within the bay and were used previously as locations to sample zooplankton and fish (W. E. Johnson, Unpublished data, Dept. Fish. Wildl., O. S. U., Dec. 1970; Frolander et al. 1971). Samples were taken in mid-channel where bottoms consisted of soft sand and shells, except at station No. 4 where decaying wood and leaves comprised the major sediments. Mean depth at the sampling sites was 14, 9, 7, and 4 m for station Nos. 1, 2, 3, and 4, respectively. Each sample consisted of a 15-min tow at 700 rpm against the current by the R/V Paiute. Based on preliminary experience, the trawl was towed with a 4:1 scope to assure proper contact with the bottom. The trawl was fitted with a body liner of 3.5 mm stretch mesh, and a cod end liner of 1.5 mm stretch mesh. The distance the trawl traveled along the bottom was determined by use of a 1-m (circumference) wheel and revolution counter attached to one skid (Fig. 2). This device permitted determination of the area sampled.

Collections of shrimp were made every 14 days, when possible, for the 15 mo study. A random sample of shrimp (ca. 150) from each tow was placed in an 8-oz jar and the remaining number of animals

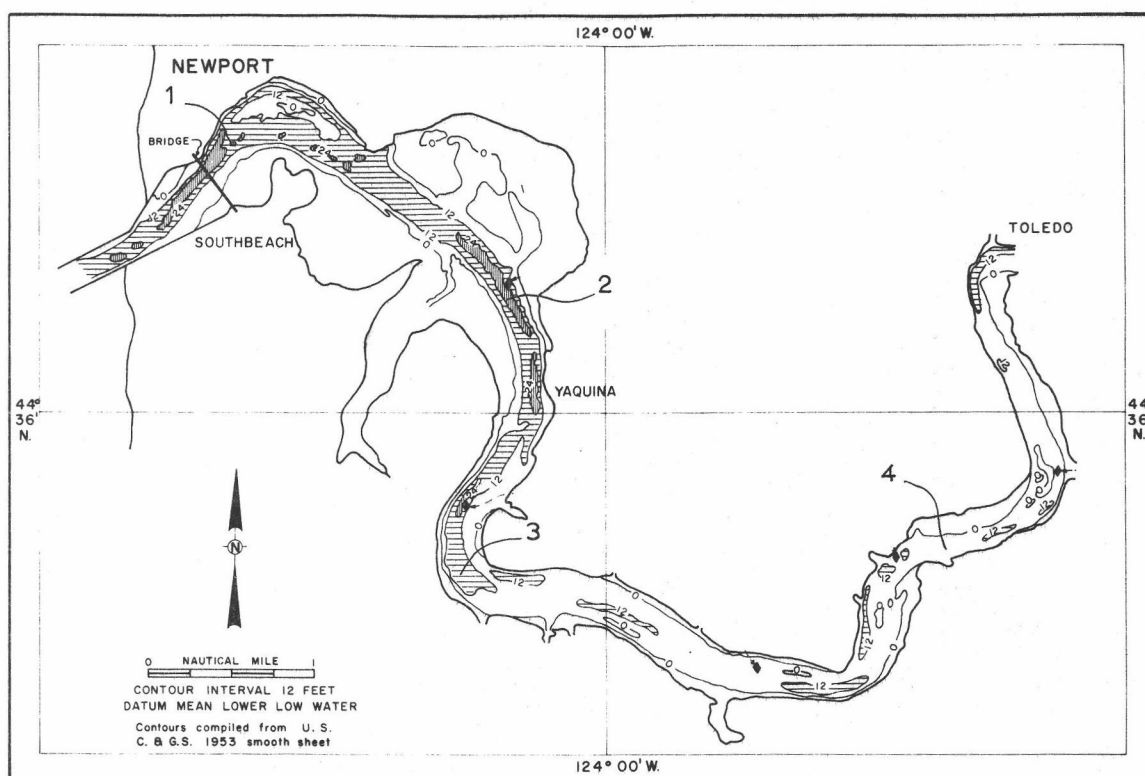


Figure 1. Map of Yaquina Bay, Oregon, showing the four sampling stations where Crangonid shrimp were collected.



Figure 2. Beam trawl, with attached 1-m wheel, used to sample Crangonid shrimp in Yaquina Bay, Oregon.

captured was estimated. Samples were initially preserved in 10% buffered Formalin and later transferred to 35% isopropyl alcohol. Water depth, salinity, and surface and bottom temperatures were recorded at each station. Salinities were determined with hydrometers (U.S. Coast and Geodetic 1950).

From the 119 collections, 4,568 C. franciscorum and 8,244 C. nigricauda were measured for total length (TL) which is defined as the distance from the tip of the rostrum to the tip of the telson. The validity of this measurement was ascertained by the regression of TL on carapace length (CL) for all age classes and sexes. The calculations indicated a constant relationship in all cases. CL is a standard measurement because it is not subject to change after death (Meredith 1952).

All TL measurements were made with dial calipers to the nearest 0.1 mm. The lengths of specimens were arithmetically averaged into 2 mm groups with odd lengths grouped with the next lower interval. The frequency of observations of the mean lengths for each 2-mm interval were then used in a weighted mean length equation

$$\sum \frac{f_i x_i}{f_{ii}}$$

where f_i = frequency of observations at each 2 mm grouping
 x_i = averaged length of the 2 mm group
 f_{ii} = Σ of all frequencies

for each age and sex groupings for sexually immature males and females, sexually mature males and females, and ovigerous females for each sampling station on each sampling day. Sexually unidentifiable shrimp were placed with identifiable, but sexually immature males and females on a 50:50 ratio. Such placement was based on the results of sampling which indicated that the sex ratio of sexually immature shrimp was 50:50 (Wenner 1972). The weighted mean lengths for each sampling day at each station were used to compare the distribution of size classes within the bay against the hydrographic data. The frequency of observations at each station on each sampling day for each age and sex grouping was used to correlate distribution of numbers against hydrographic data.

Using the statistical analyses of the distributional changes for the two species of shrimp, and the correlation of these changes with hydrographic data, a description of the patterns of migration within the bay system was attempted. Due to the large inherent variation with the sampling procedure and the number of parameters observed, the results (coefficient of determination [R^2] and F-test for significance of regression) yielded only general trends in migration patterns. The F values for the test of significance of regressions were determined by dividing the mean squares due to regression by the mean square due to residual variation; both of which were obtained

from the analysis of variance table. The F-test tests the null hypothesis that the true value B_1 (slope) is zero, or that there is no relationship between distribution and hydrographic data. If the calculated F value exceeds the tabular F value we reject the hypothesis $H_0: B_1 = 0$ and can assume with 95-99% confidence that there is a linear relationship between numbers or size and hydrographic data (Draper and Smith 1966). R^2 values were statistically low, but the F-tests indicated significant relationships for the effects of temperature, salinity, and temperature-salinity interaction on the distribution of numbers and size.

Sex of all specimens was determined by examination of three sexual characteristics under a dissecting microscope: (1) the endopodites of the first and second pleopods are sexually dimorphic as illustrated by Lloyd and Yonge (1947) and Meredith (1952). The endopodite of the first pleopod is short and curved inward for males, and long and straight for females. (2) The endopodite of the second pleopod of developing and mature males possess an appendix masculina, whereas for females the structure is similar to those on the first and third pleopod. (3) The location of the gonopore is at the base of the fifth pair of walking legs in males and at the base of the third pair of walking legs in females. Using a combination of these characteristics I determined the sex of specimens greater than 22 mm for C. nigricauda and greater than 26 mm for C. franciscorum.

Sexual maturity was determined from squashes of testis (Feulgen squash method for testis [Darlington and La Cour 1969]) and squashes of ovaries (untreated) examined under a phase-contrast microscope. The presence of sperm indicated maturity for males, and the presence of ova on the egg pad or ripe ovaries (stage 7 condition described and illustrated by Meredith [1952]) indicated maturity for females.

The relationship between fecundity and TL was determined by the method of Price (1962). Eggs from each mass (pad) were measured for their largest diameter, and inspected to determine stage of development. The four stages of egg development used in this study (Fig. 3) were patterned after those described by Meredith (1952).

- A - eggs spherical, yolk uniform
- B - eggs oblong, larval hemisphere distinct from yolk
- C - eye pigment visible
- D - eggs near hatching with large eyes and abdomen free of head

To minimize the effect of possible egg loss during incubation or handling, only the early developmental stages (A and B) were enumerated for determination of fecundity relationships. For fecundity determinations, 15 ovigerous females of each species, ranging in size from 41.0-61.4 mm for C. nigricauda and 47.8-67.4 mm for C. franciscorum, were stripped of their eggs and the eggs enumerated.

A
(ca. 500 μ)



B
(ca. 580 μ)

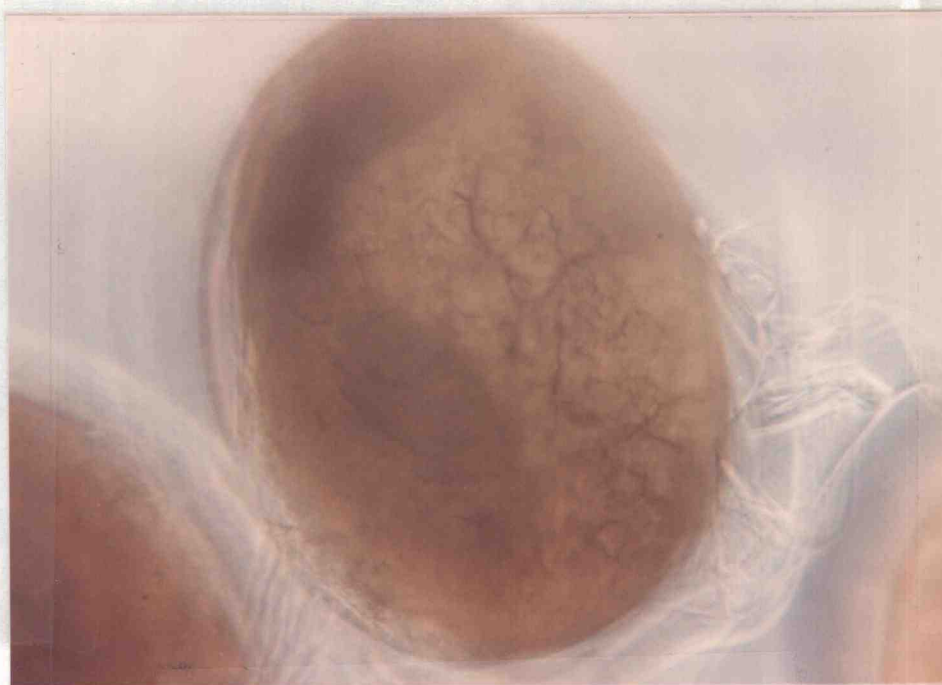


Figure 3. Stages of egg development for Crangon nigricauda and C. franciscorum showing (A) egg spherical, yolk uniform, (B) egg oblong, larval hemisphere distinct from yolk, (C) eye pigment visible, (D) egg near hatching with large eyes and abdomen free of head.

C
(ca. 600 μ .)



D
(ca. 630 μ .)



Figure 3. (Continued)

Growth was determined by analysis of the length-frequency distributions of the sexually unrecognizable pre-adult males and females combined, and the sexually recognizable males and females. The length-frequency distributions represent collections from the four sampling stations where the length-frequencies were pooled according to the date of collection. The growth rates of the pre-adults were estimated by regression of the modal peaks of length-frequency distributions with the numerical value of the week in question (e. g., the collections of Jan. 18, 1971 = week No. 3 and the collections on May 7, 1971 = week No. 18).

RESULTS

Distribution

C. nigricauda

The young and adults of C. nigricauda show a general trend of decreasing in numbers with increasing water temperature; ovigerous females, however, give a non-significant response to temperature (Table 1). For young males of C. nigricauda the effect is a decrease of approximately three individuals per trawl per degree increase in temperature. Temperature values over the sampling period at each station are plotted in Fig. 4, and changes in abundance of shrimp at each sampling station are plotted in Figs. 5, 6. The range of temperature values where immature C. nigricauda were collected was 6.5-16.5 C; for adults the range was 5.2-16.5 C. Ovigerous females were collected in water ranging from 6.8-12.9 C, with 94% found between 8-11 C (Fig. 4, Table 2).

A slight increase in numbers of C. nigricauda was associated with increasing salinity; the effect on all age classes was significant (F-test) at the 1% level (Table 3). Immature shrimp show a greater response to both temperature and salinity than do adults. The salinity values at each sampling station are plotted in Fig. 4. With few exceptions, C. nigricauda normally was observed in waters with

Table 1. Slope and R^2 values describing the relationship of temperature to size (length) and abundance (frequency) of each age and sex group of Crangon nigricauda and C. franciscorum in Yaquina Bay.

Variables	Slope	R^2
<u>C. nigricauda</u>		
<u>Temperature-frequency</u>		
young males	-2.646*	0.055
young females	-3.384**	0.060
mature males	-1.195*	0.048
mature females	-0.577*	0.051
ovigerous females	-0.092	0.013
<u>Temperature-size</u>		
young males	-0.766*	0.062
young females	-0.944*	0.073
mature males	-1.794**	0.132
mature females	-2.603**	0.126
ovigerous females	-0.663	0.015
<u>C. franciscorum</u>		
<u>Temperature frequency</u>		
young males	+2.996**	0.354
young females	+3.010**	0.181
mature males	-0.185	0.002
mature females	-0.757**	0.098
ovigerous females	-0.015	0.001
<u>Temperature-size</u>		
young males	+0.874*	0.061
young females	-0.535	0.021
mature males	-0.168	0.003
mature females	-1.434*	0.068
ovigerous females	+0.446**	0.113

* F-statistic significant at 5% level

** F-statistic significant at 1% level

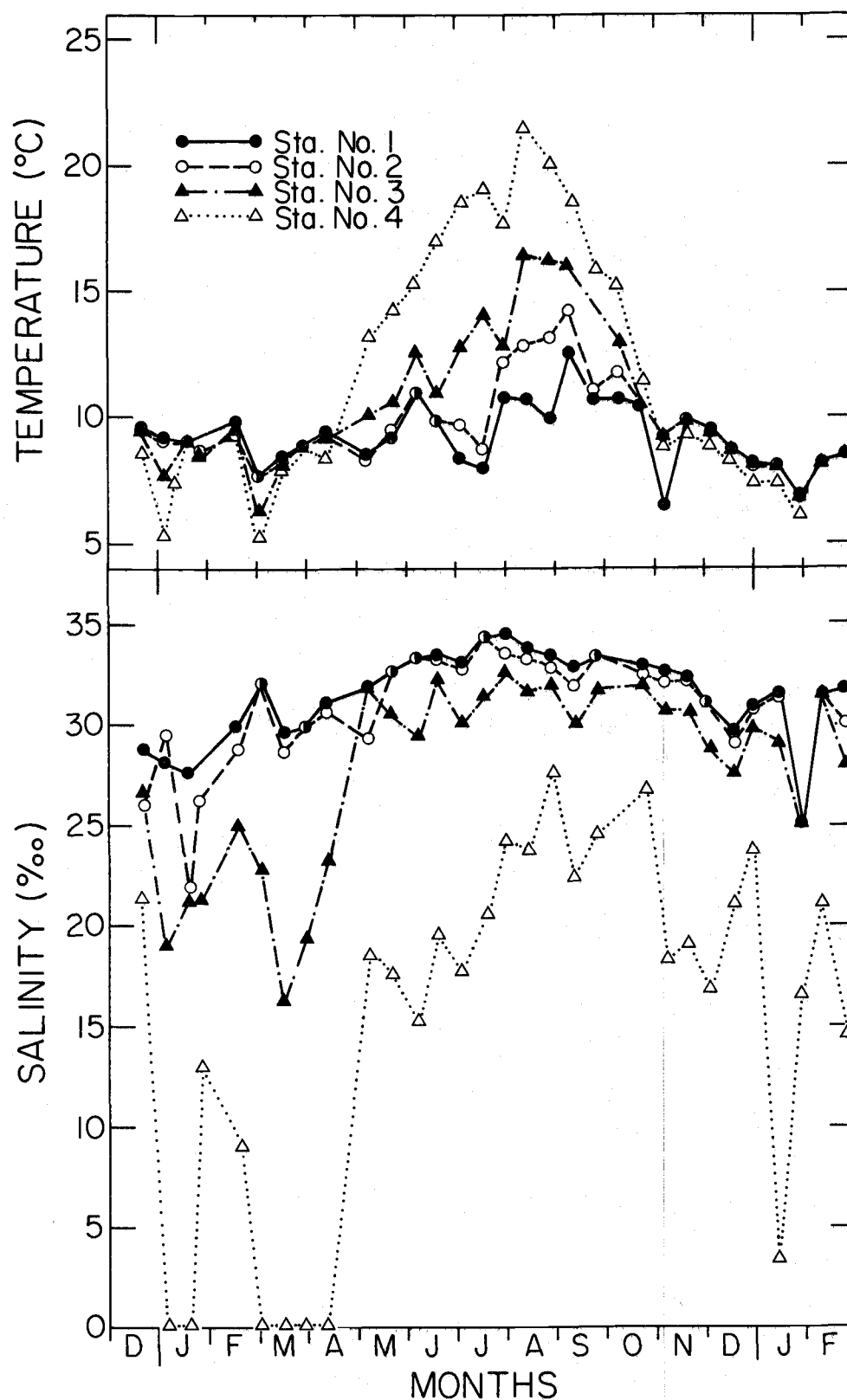


Figure 4. Temperature and salinity values by date of collection at four Crangon sampling stations in Yaquina Bay, Oregon, 1970-72.

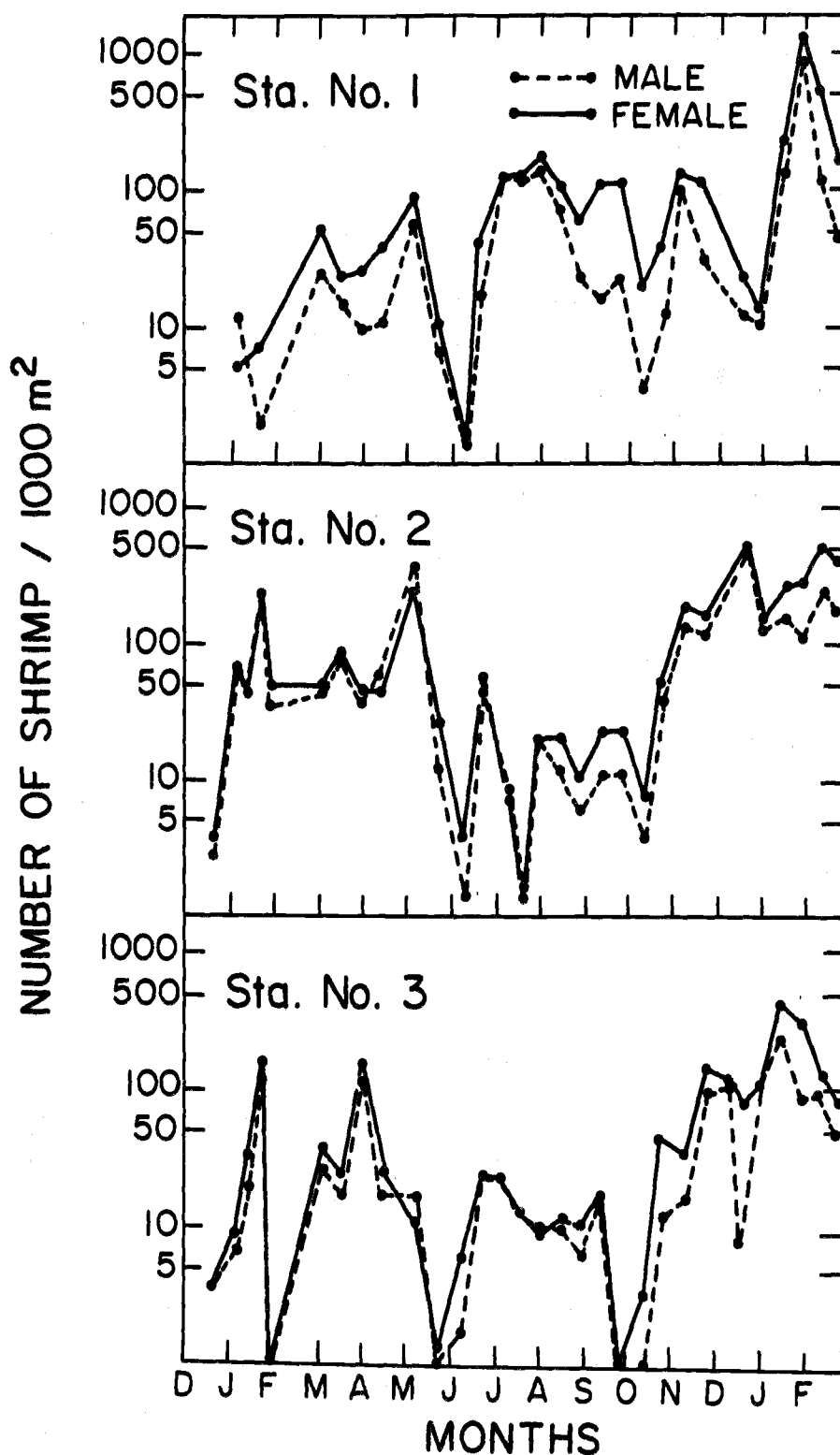


Figure 5. Relative abundance and date of collection of sexually immature Crangon nigricauda from three sampling stations in Yaquina Bay, Oregon, 1970-72.

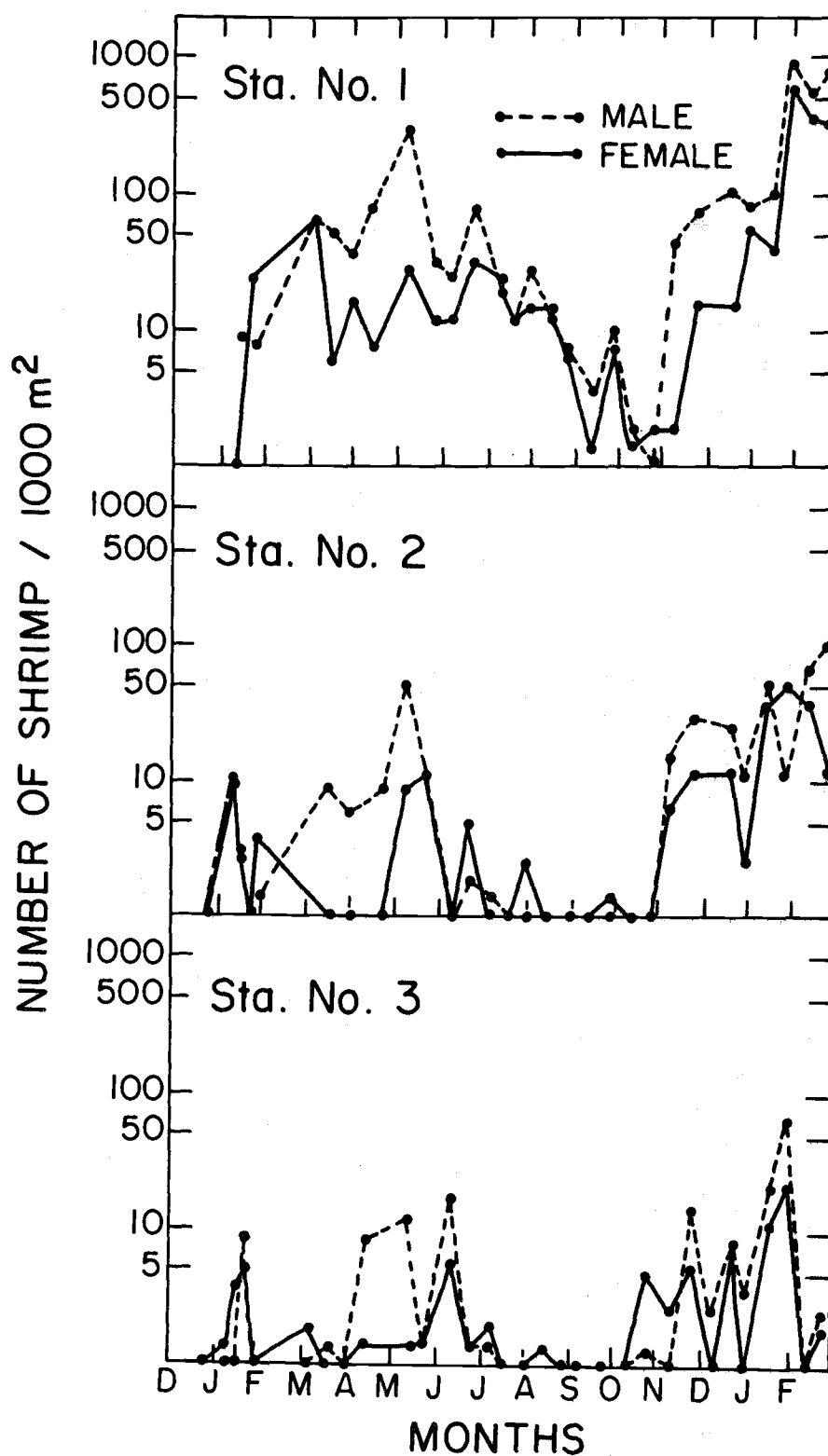


Figure 6. Relative abundance and date of collection of sexually mature *Crangon nigricauda* from three sampling stations in Yaquina Bay, Oregon, 1970-72.

Table 2. Capture point (station number [St #]), date of collection, and stage of egg development for ovigerous Crangon nigricauda from Yaquina Bay, Oregon.

Date	A-stage Egg			B-stage Egg			C-stage Egg			D-stage Egg		
	St # 1	St # 2	St # 3	St # 1	St # 2	St # 3	St # 1	St # 2	St # 3	St # 1	St # 2	St # 3
1-11-71		1										
1-18-71	3						1			1		
1-25-71												
3- 1-71	4									1		
3-15-71												
3-29-71	4						1			1		
4-12-71	1			1								
5- 7-71				1								
5-21-71	2			2								
6- 6-71	4			3			1					
6-18-71	4			2			1					
7- 2-71	1		2	11			3					
7-16-71	2			5			2					
7-30-71		1		5			1			1		
8-13-71	1			1			1			7		1
8-27-71				5						3		
9-10-71												
9-24-71				1								
12-17-71	1											
12-30-71	3			6								
1-14-72				1								
1-28-72	2			1								
2-11-72												
2-25-72	3			2			3					

Table 3. Slope and R^2 values describing the relationship of salinity to size (length) and abundance (frequency) of each age and sex group of Crangon nigricauda and C. franciscorum in Yaquina Bay.

Variables	Slope	R^2
<u>C. nigricauda</u>		
<u>Salinity-frequency</u>		
young males	+1.243**	0.086
young females	+1.848**	0.127
mature males	+0.605**	0.087
mature females	+0.258**	0.072
ovigerous females	+0.084**	0.075
<u>Salinity-size</u>		
young males	+0.789**	0.487
young females	+0.675**	0.260
mature males	+0.998**	0.274
mature females	+1.398**	0.253
ovigerous females	+0.843**	0.122
<u>C. franciscorum</u>		
<u>Salinity-frequency</u>		
young males	-0.570**	0.093
young females	-1.330**	0.253
mature males	-0.254	0.027
mature females	-0.270**	0.089
ovigerous females	+0.017	0.006
<u>Salinity-size</u>		
young males	-0.906**	0.341
young females	-0.911**	0.176
mature males	-0.279	0.015
mature females	-0.368	0.044
ovigerous females	+0.821**	0.158

** F-statistic significant at 1% level.

> 19 ppt salinity (Figs. 4, 5, 6). Ovigerous females were not seen in water < 25.4 ppt and most occurred in water \geq 32 ppt (Fig. 4, Table 2) (the maximum salinity observed in the bay was 34.5 ppt).

The regression of size of individuals against temperature and salinity reveals trends which possibly influence the migration of size and age classes. The effect of temperature is such that larger animals appear to leave an area with increasing temperature while the likelihood of finding smaller individuals increases (Table 1). The effect of temperature is greater on adults than on immatures (Table 1). Though the general trend is for an increase in numbers (primarily immatures) with increasing temperature, there is a lower bound to this influence at about 8.5 C (Figs. 4, 5, 6). Salinity has the opposite effect of temperature. Here, increases in salinity are associated with the occurrence of larger individuals in an area. Consequently, smaller shrimp tend to occur up-bay at station No. 3. The hydrographic factors which most strongly effect the adult population appear to be temperature in the summer and salinity in the winter.

The fact that both temperature and salinity are separate parameters which effect the distribution of these shrimp is shown in their interaction regression on numbers and size (Table 4). This temperature-salinity (T-S) interaction shows an increase in the R^2 values greater than the sum of the two variables (Mendenhall 1963). The result of the interaction of salinity and temperature seems to

Table 4. New slope and R^2 values describing the relationship of the temperature-salinity (T-S) interaction to size (length) and abundance (frequency) of each age and sex group of Crangon nigricauda and C. franciscorum from Yaquina Bay.

Variables	Slope (temp.)	Slope (salinity)	R^2
<u>C. nigricauda</u>			
<u>T-S - frequency</u>			
young males	-3.051**	+1.39	0.156
young females	-4.028**	+2.04	0.208
mature males	-1.456**	+0.67	0.154
mature females	-0.682**	+0.29	0.140
ovigerous females	-0.122**	+0.09	0.097
<u>T-S - size</u>			
young males	-0.776**	+0.80	0.552
young females	-0.984**	+0.69	0.335
mature males	-1.859**	+1.02	0.398
mature females	-2.598**	+1.43	0.371
ovigerous females	-0.655**	+0.85	0.132
<u>C. franciscorum</u>			
<u>T-S - frequency</u>			
young males	+3.260**	-0.73	0.500
young females	+3.525**	-1.50	0.491
mature males	-0.113	-0.25	0.027
mature females	-0.680**	-0.24	0.164
ovigerous females	-0.016**	+0.02	0.006
<u>T-S - size</u>			
young males	+0.930**	-0.92	0.388
young females	-0.508**	-0.90	0.184
mature males	-0.089	-0.28	0.016
mature females	-1.422*	-0.35	0.074
ovigerous females	+0.454**	+0.81	0.160

* F-statistic significant at 5% level

** F-statistic significant at 1% level

limit C. nigricauda to the three down-bay collection sites where influence of the oceanic environment produces relatively high salinity and low temperature (Fig. 4). Elevated summer temperatures in the mid to upper sections of the bay apparently restrict the up-river migration of C. nigricauda, but increasing salinity from low run-off enables these shrimp to move up-bay as far as station No. 3. High temperatures help to explain the disappearance of adults from station Nos. 2 and 3 from June to October, and the decrease in numbers at station No. 1 in early September (Figs. 5, 6). There is a corresponding increase in shrimp abundance as the fall temperatures decrease.

Much of the apparent contradictory peaks and dips in the graphs of abundance (Figs. 5, 6) are attributed to recruitment of new age classes (Fig. 7), and possibly to an influx of animals from the marine environment west of station No. 1.

C. franciscorum

The abundance of young C. franciscorum, unlike C. nigricauda, shows a positive reaction to water temperature (Table 1). A slight reverse effect is seen with adult females. The effects of temperature on abundance of adult males and ovigerous females is not significant (Table 1). The temperature range for occurrence of young and adult C. franciscorum was 5.2-21.3 C, and for ovigerous females was 6.8-19.2 C.

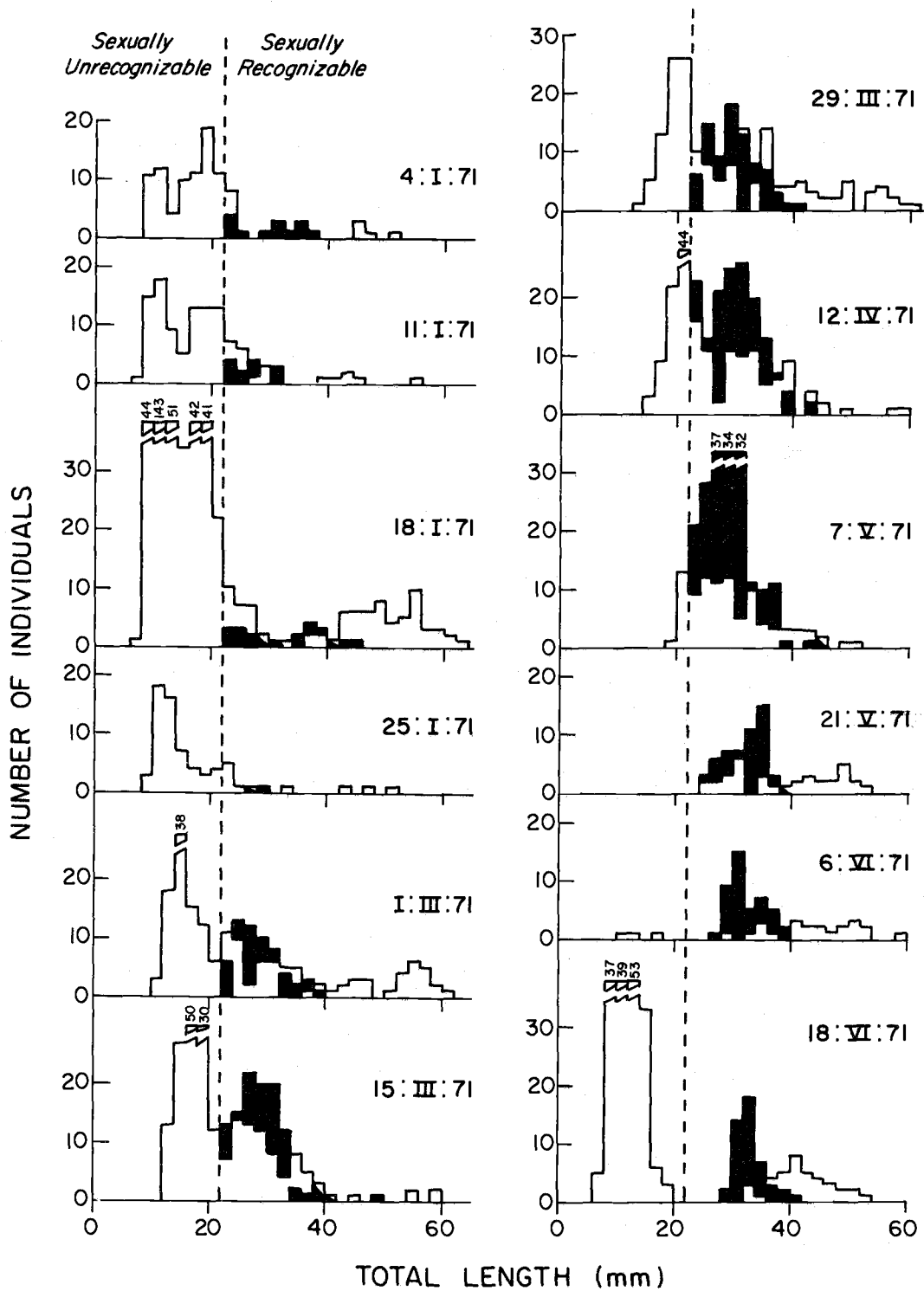


Figure 7. Length-frequency histograms of sexually unrecognizable (<22 mm TL) and sexually recognizable (≥ 22 mm TL) *Crangon nigricauda* in Yaquina Bay, Oregon, 1971-72. Data pooled for all sampling stations by date of capture. For sexually recognizable shrimp, solid bars = males, and open bars = females.

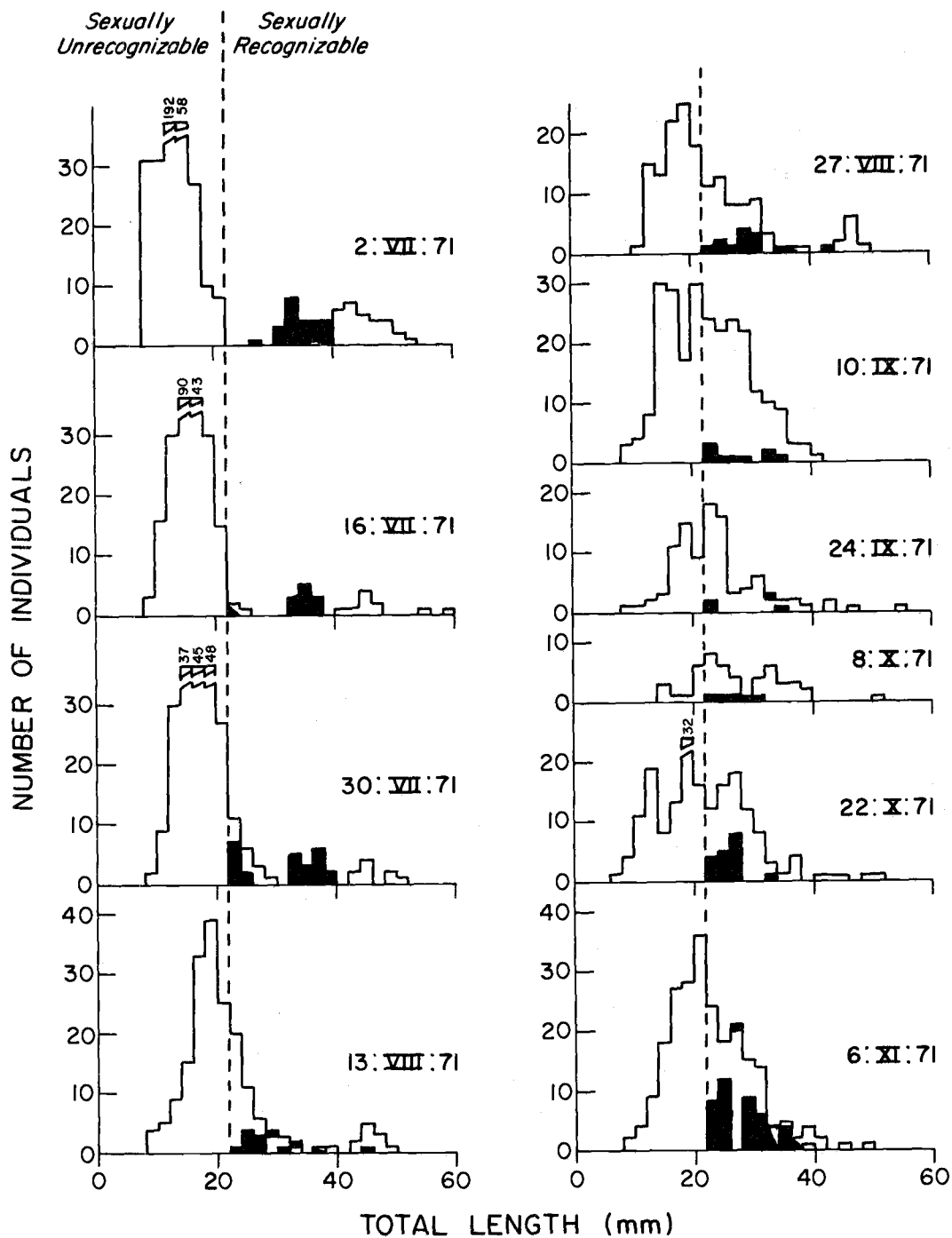


Figure 7. (Continued)

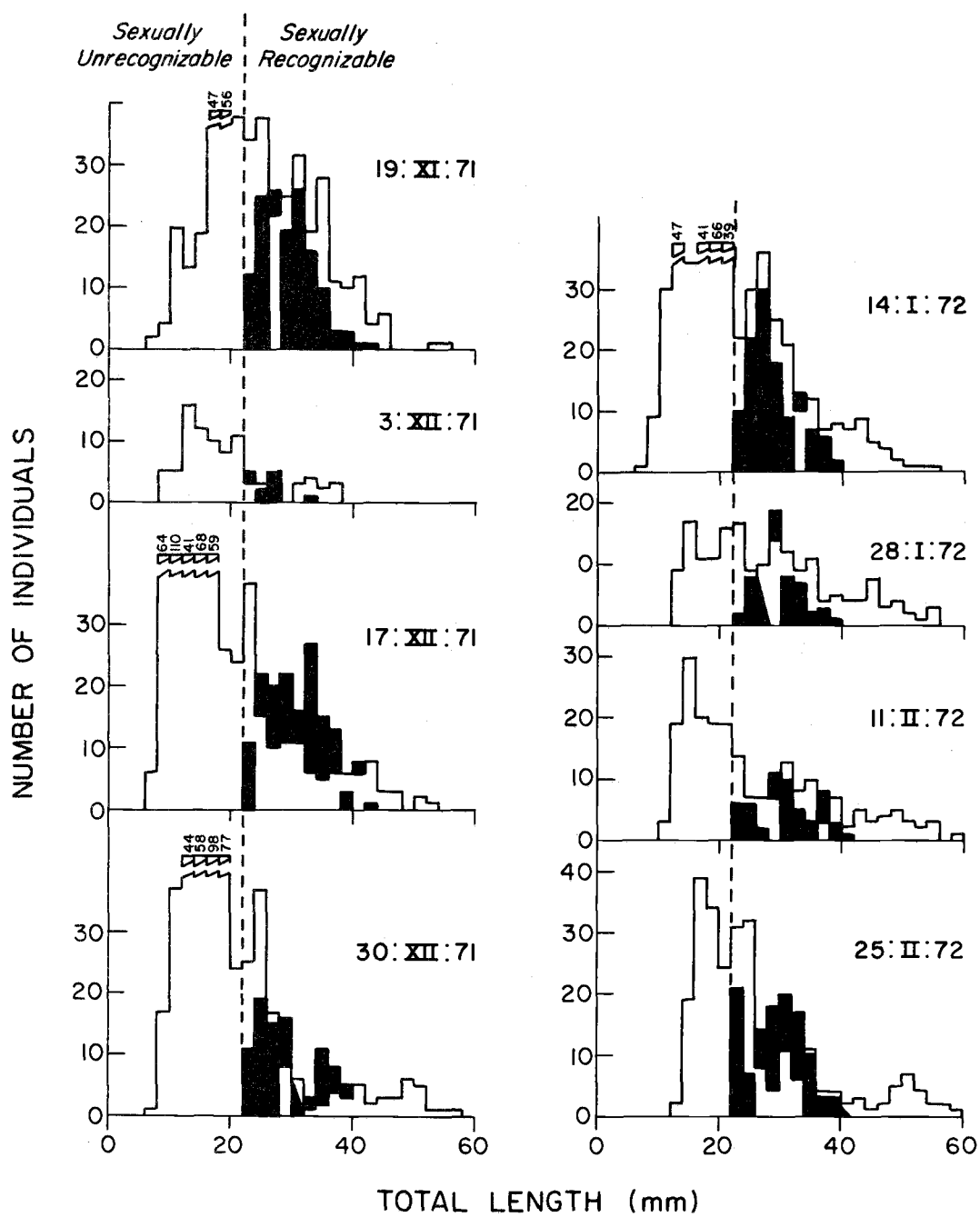


Figure 7. (Continued)

The effect of salinity on abundance of C. franciscorum is negative, with young females showing the greatest response to salinity followed by young males (Table 3). The negative effect of salinity on abundance of adults is most pronounced when salinity drops below 5 ppt (Figs. 4, 9). The ranges of salinity where young and adult C. franciscorum were collected was 0.2-34.4 ppt. Ovigerous females showed a positive response to salinity (Table 3) and were obtained only in waters from 14.6-34.4 ppt.

In C. franciscorum the temperature-size relationship is positive for young males and ovigerous females, and negative for young and adult females (Table 1). The salinity-size relationship for young and adults is negative for all but ovigerous females which show a positive response (Table 3). Responses of non-ovigerous adults to changes in salinity are not significant at the 5% level (Table 3). Of the two hydrographic parameters, salinity is more important though temperature shifts can cause large changes in abundance of C. franciscorum.

The T-S interaction indicates that both parameters are active in the cause of changes in the distribution of C. franciscorum (Table 4). The interaction effect is seen most clearly in immatures, where high salinity water usually retards the down-bay migration, but increases in temperature during the summer allow a movement into these waters. The outcome of these hydrographic influences on C. franciscorum indicates that this species thrives on the fringe of the oceanic environment (Figs. 4, 8, 9).

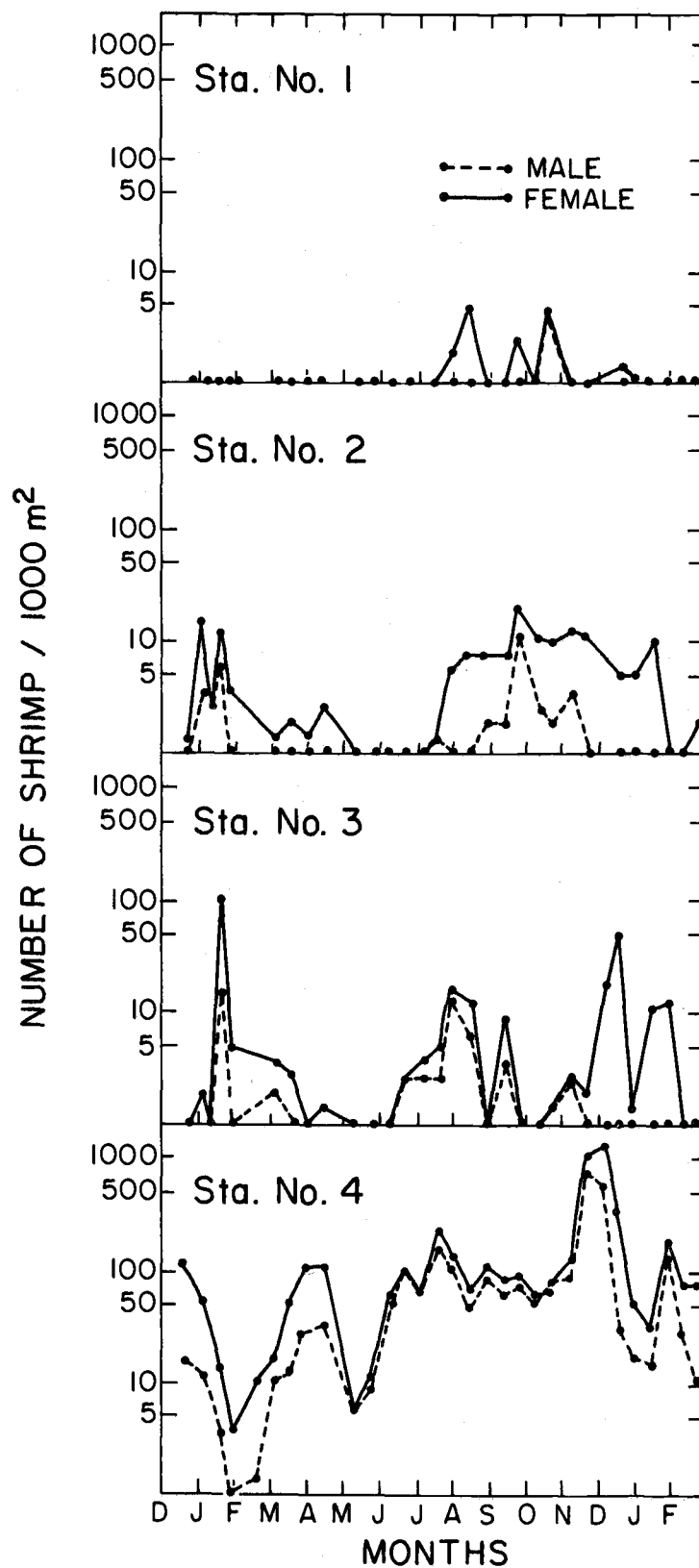


Figure 8. Relative abundance and date of collection of sexually immature Crangon franciscorum from four sampling stations in Yaquina Bay, Oregon, 1970-72.

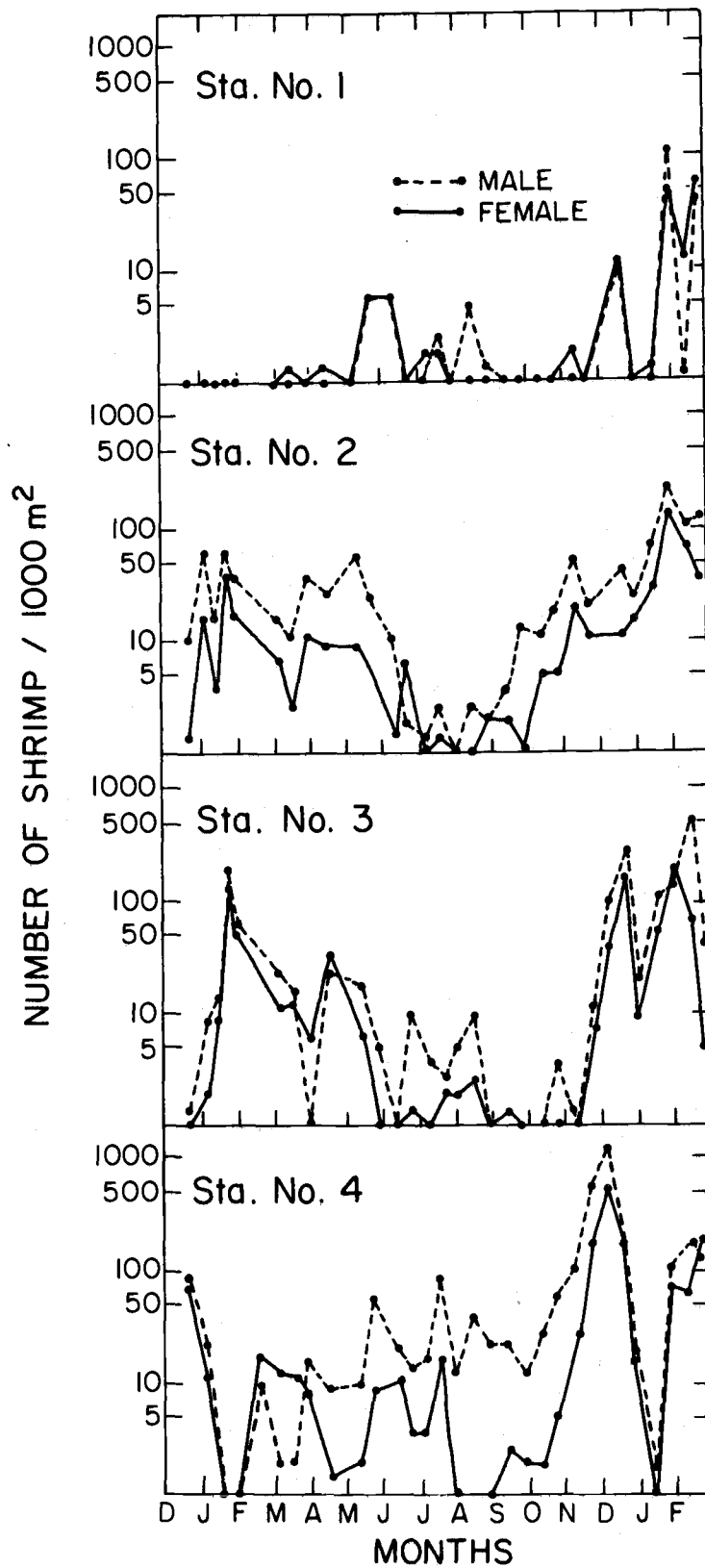


Figure 9. Relative abundance and date of collection of sexually mature Crangon franciscorum from four sampling stations in Yaquina Bay, Oregon, 1970-72.

Reproduction

C. nigricauda

A total of 115 ovigerous C. nigricauda were collected in the 15 months of sampling. The mean TL of the ovigerous females was 49.3 mm, and the range was 36.2-61.4 mm. During the breeding season 95% of the females were sexually mature after attaining 40 mm TL, and had either eggs on the egg pad or a stage 7 ovary.

Microscopic examination of 60 males showed that most were mature at ≥ 28 mm TL, although five males were mature at 26 mm, and two > 28 mm did not contain ripe sperm. The sperm of C. nigricauda and C. franciscorum (Fig. 10) is similar to that described by Kume and Dan (1957) for natantian shrimp.

Spawning season of C. nigricauda within the bay system is from December to mid-August as evidenced by the presence of A-stage eggs (Table 2) which are laid soon after copulation (Lloyd and Yonge 1947). There are two spawning peaks within this season as indicated by the bimodal curve of recruitment to the population (Fig. 7). The first peak occurs from December through March, where 88% of the ovigerous females collected are large (> 47 mm TL) and presumably older individuals. The second peak occurs from mid-May to mid-August, and consists of small and large ovigerous females. The large females most likely are repeat spawners from the first peak of

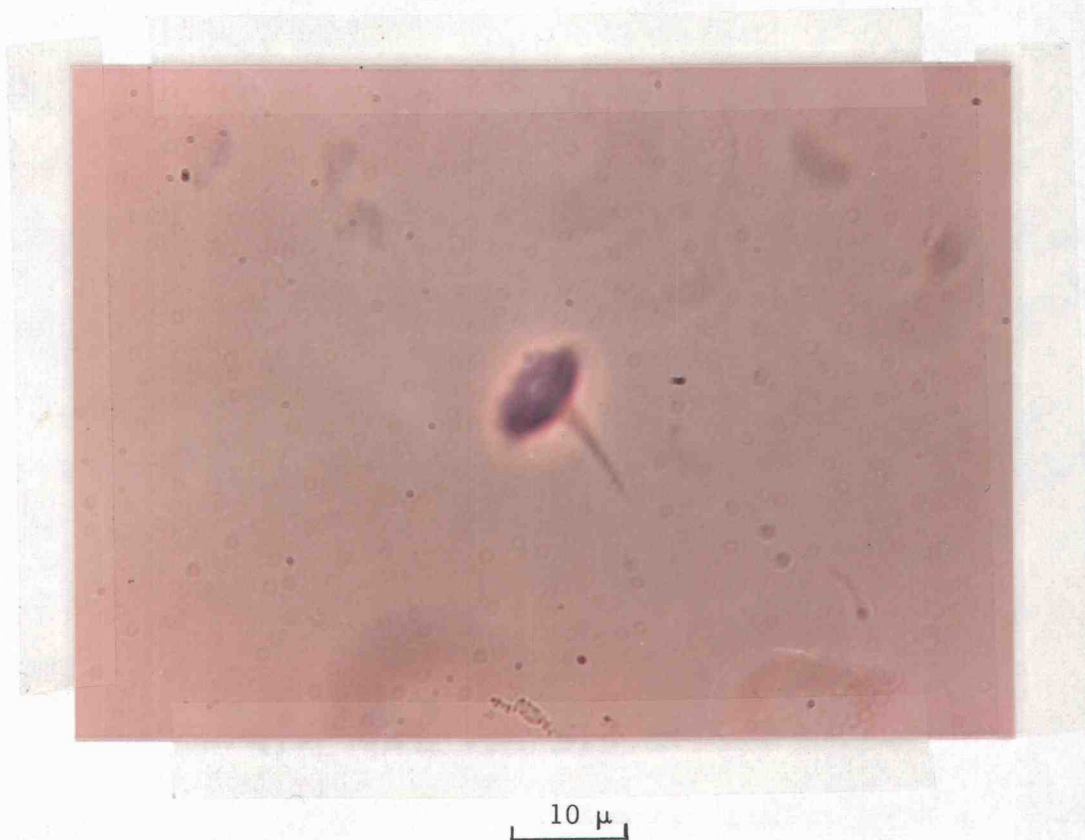


Figure 10. Photomicrograph of a sperm of Crangon nigricauda taken during the 1972 spawning season in Yaquina Bay.

the year (Table 5). Examination of the number of ovigerous females present indicates the second spawn to be the larger (Table 2).

An apparent spawning migration occurs for this species. All but 5 of the 115 ovigerous females were collected at station No. 1. A "disappearance" from the area of abundance, from mid-September to December of ovigerous females whose eggs had not fully developed exemplifies the migration (Table 2).

The reproductive potential of individual C. nigricauda is described by $Y = -5878.9 + 200.7 (X)$, which is the regression of fecundity on TL. Here, Y is the fecundity of a shrimp of a given size, -5878.9 is the intercept (if the total length of the female was zero) of the y-axis, +200.7 is the slope of the regression line; and (X) is the total length of the female in question. The R^2 value is 0.91. The observed range of fecundity was 2,393-7,000 eggs for 43.2 and 60.2 mm TL females, respectively. Based on the regression equation, the largest female would carry 6,443 eggs and the smallest would carry 1,386 eggs. The mean number of eggs per female would be about 4,016. This means that the smaller spawning peak, which consists of large individuals, from December-March actually contributes a significant proportion of eggs to the population as illustrated by the substantial recruitment of young in July (Fig. 7).

Table 5. Frequency, location and date of capture of small (< 47 mm TL) and large (\geq 47 mm TL) ovigerous Crangon nigricauda collected in Yaquina Bay.

Date	Station #1		Station #2		Station #3	
	Small	Large	Small	Large	Small	Large
1-11-71				1		
1-18-71		5				
3- 1-71		5				
3-29-71		6				
4-12-71		2				
5- 7-71		1				
5-21-71		4				
6- 6-71	1	7				
6-18-71	1	6				
7- 2-71	10	5			1	1
7-16-71	6	3				
7-30-71	5	2	1			
8-13-71	7	3			1	
8-27-71	4	4				
9-24-71		1				
12-17-71	1					
12-30-71	2	7				
1-14-72	1					
1-28-72		3				
2-25-72	1	7				

C. franciscorum

One hundred and twenty ovigerous C. franciscorum were collected with the mean size being 56.8 mm TL. The largest ovigerous female was 68.8 mm and the smallest was 43.6 mm TL. Sexual maturity for these females appears to take place at 48.0 mm with most having either a stage 7 ovary or incubating eggs during the breeding season. The greatest percentage of males were mature at 34.0 mm TL.

The spawning season for C. franciscorum in Yaquina Bay is bimodal and occurs from December to mid-August (Fig. 11, Table 6). As with C. nigricauda, the larger and presumably older females appear at the start of the season from December to March, when only 5% of those with eggs were < 55 mm TL (Table 7). The second and largest spawn, April to mid-August, included incoming and repeat spawners (Fig. 11, Table 6).

A "spawning migration" of these normally low saline inhabiting shrimp is indicated by the occurrence of ovigerous females in high salinity waters of the bay. This was the case for all but 10.8% of the 120 ovigerous females collected (Table 7, Fig. 4). When waters of the lower three collection stations are increasing in salinity from March through July, and in June and July at station No. 4, peaks appear in the abundance of females (Fig. 9, Table 7) which can best

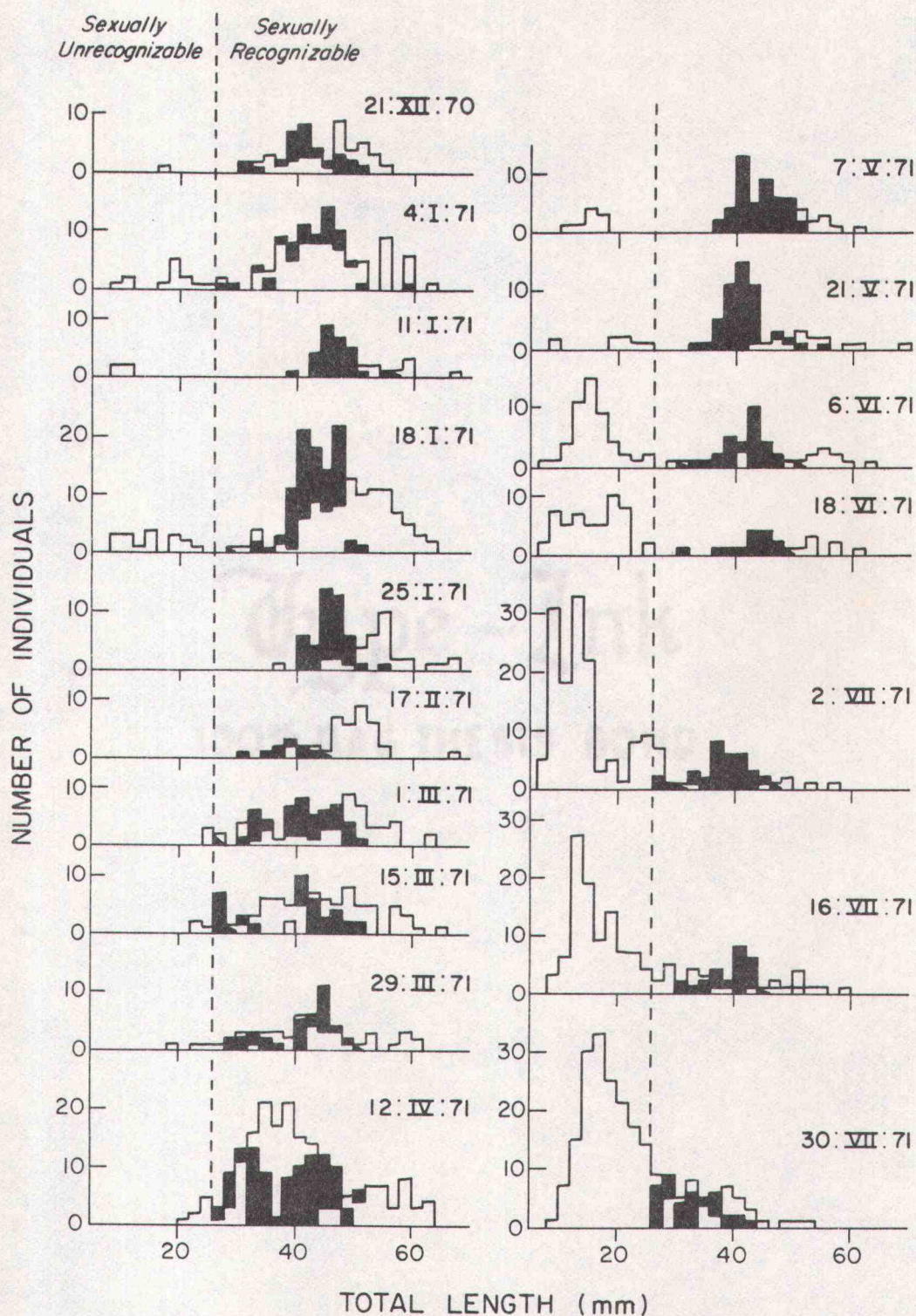


Figure 11. Length-frequency histograms of sexually unrecognizable (<26 mm TL) and sexually recognizable (≥ 26 mm TL) *Crangon franciscorum* in Yaquina Bay, Oregon, 1970-72. Data pooled for all sampling stations by date of capture. For sexually recognizable shrimp, solid bars = males, and open bars = females.

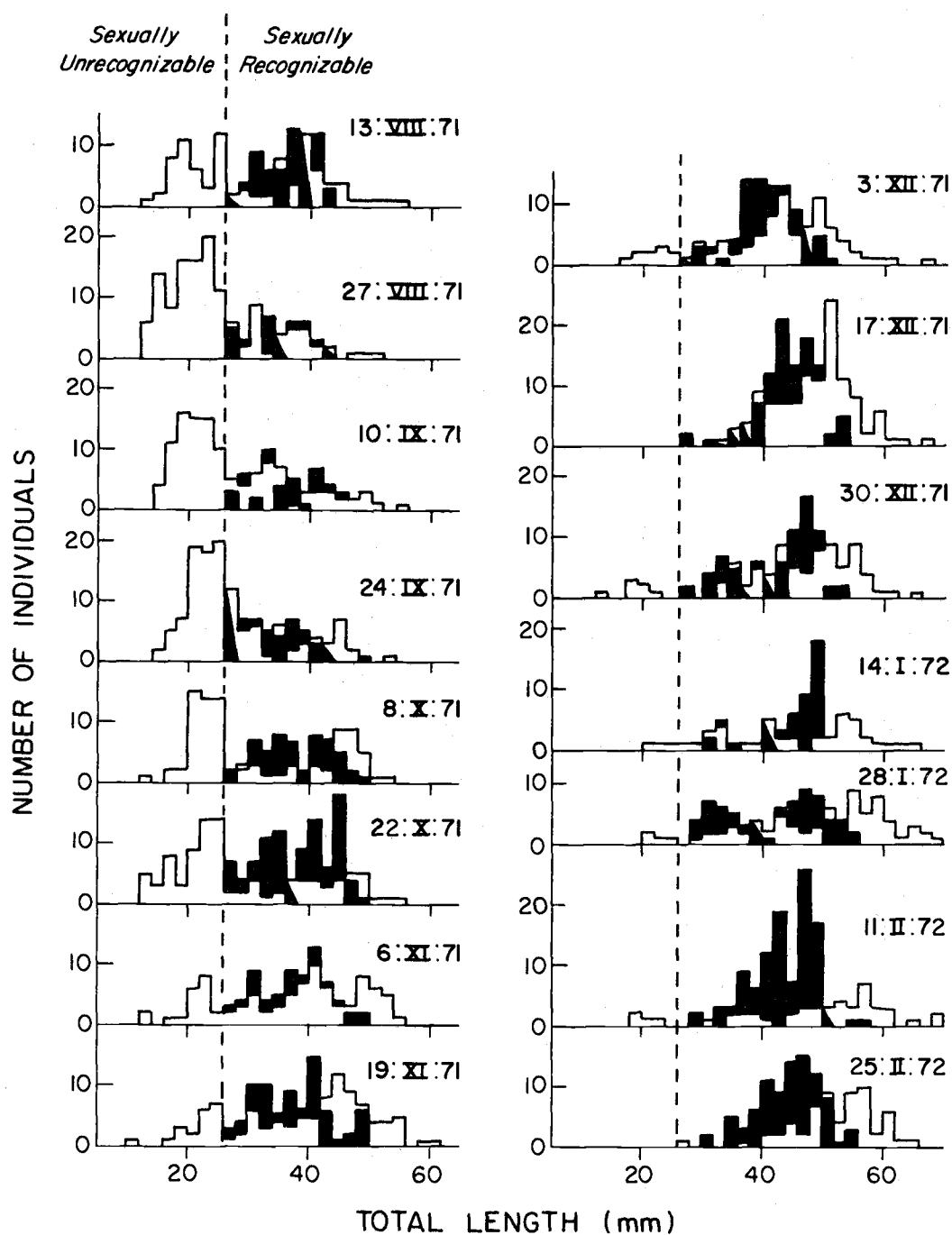


Figure 11. (Continued)

Table 6. Capture point (station number [St#]), date of collection, and stage of egg development of ovigerous Crangon franciscorum collected in Yaquina Bay.

Date	A-stage Egg				B-stage Egg				C-stage Egg				D-stage Egg			
	St#	St#	St#	St#	St#	St#	St#	St#	St#	St#	St#	St#	St#	St#	St#	St#
	1	2	3	4	1	2	3	4	1	2	3	St#	1	2	3	4
1- 4-71		1				1										
1-11-71			1													
1-18-71		4	5				1									
1-25-71		4	1													
3- 1-71		1				1										
3-15-71							1									
3-29-71		4				1										
4-12-71		3	14		1						1			1		
5- 7-71		1	2	1		2										
5-21-71				1	3								2			
6- 6-71				3	2	1			1				2			
6-18-71				1		1								2	1	
7- 2-71				1									2			2
7-16-71				3	1									1	1	
7-30-71			1				1								2	
8-13-71			1				2								1	
12-17-71	2															
12-30-71		2	1													
1-14-72			1													
1-28-72	1	6	2								1					
2-11-72	1	2					3									
2-25-72	1	3		1	2											

Table 7. Data showing the frequency, location, and date of capture of small (< 55 mm TL) and large (> 55 mm TL) ovigerous Crangon franciscorum in Yaquina Bay, and the percent of mature females bearing eggs.

Date	Station #1			Station #2			Station #3			Station #4		
	Small	Large	%	Small	Large	%	Small	Large	%	Small	Large	%
1- 4-71				2		16.7						
1-11-71							1	16.7				
1-18-71					4	18.2	6	15.0				
1-25-71				1	3	23.5	1	8.3				
3- 1-71					2	33.3						
3-15-71							1	8.3				
3-29-71				1	4	62.5						
4-12-71		1	100.0		4	44.4	4	11	46.7			
5- 7-71				1		100.0	2	2	50.0	1		50.0
5-21-71	1	4	83.3							1		20.0
6- 6-71	2	3	100.0		1	100.0				3		60.0
6-18-71				2	1	50.0	1		100.0		1	100.0
7- 2-71		2	100.0							2	1	75.0
7-16-71	1		100.0		1	100.0		1	100.0	3		60.0
7-30-71							4		100.0			
8-13-71							4		100.0			
12-17-71		2	22.2									
12-30-71					2	15.4		1	11.1			
1-14-72								1	8.3			
1-28-72		1	50.0		6	46.2		3	10.5			
2-11-72		1	100.0		2	16.7		3	60.0			
2-25-72		3	75.0		3	37.5					1	2.7

be explained by a spawning migration. Ovigerous females are present during the first peak, when salinity is > 21 ppt and temperature is $6.7-9.1$ C, and during the second peak when salinity is ≥ 30 ppt (except for one collection) and temperature is $8.1-16.5$ C at the lower three collection sites. At station No. 4 only one ovigerous female was captured outside the May through July period when salinities were $15-20$ ppt and temperature was $13-19$ C. No ovigerous C. franciscorum were observed in salinities < 14.8 ppt. The males appear to migrate with the females during the spawning season. As with C. nigricauda there is a "disappearance," from mid-August to December, of ovigerous females whose eggs were not fully developed.

The reproductive potential of individual C. franciscorum is described by the regression of fecundity on TL which was $Y = -5338.7 + 156.1 (X)$, $R^2 = 0.95$. The observed range of fecundity was $1,923-4,764$ eggs for 47.8 and 67.4 mm TL females, respectively. Based on the regression equation, the largest ovigerous female would have a fecundity of $5,401$ eggs and the smallest $1,467$ eggs, with a mean fecundity of $3,528$ eggs. This parallels the situation observed in C. nigricauda. A comparison of the two species shows that C. nigricauda has a greater reproductive potential even though C. franciscorum is the larger of the two.

In both C. nigricauda and C. franciscorum, I noted some females with apparent A-stage eggs in which eggs were broken and the

whole pad was falling apart. Most of these appear to be the result of unsuccessful fertilization and subsequent degeneration of the egg pad (Lloyd and Yonge 1947). A few of these apparent A-stage eggs may have been spent egg cases.

Repeat spawning was demonstrated in both species. The proof was in the presence of ovarian stages 5-7 in females early in the spawning season which had eggs on their egg pad. The stage 7 ovary was seen only on ovigerous females with C- and D-type eggs and pre-egg bearing mature females.

Of all the caridian shrimp (Appendix) collected from Yaquina Bay, only the females of C. franciscorum exhibited noticeable parasites. Argeia pugettensis (Richardson 1905), a bopyroidean branchial isopod, was observed in females ≥ 31.4 mm TL during the months of December through mid-June. The mean size of infected females was 44.8 mm. Because none of the infected adult females were "in berry" during the normal spawning season, I concluded that the infection curtails egg production.

Growth

C. nigricauda

The bimodal recruitment (Fig. 7) of C. nigricauda indicates two groups of shrimp with separate rates of growth. Group I is the

product of the pre- to mid-spring hatch, the larvae of which are planktonic until about mid-June. The young grow steadily until December-March, when they mature and eggs are first laid (Table 2, Fig. 7). Along with this group of maturing shrimp is a group of large mature females which spawn in December and January (Table 5). Most of these large females are undoubtedly the remains of the females of Group II (defined below) which spawned in the summer and help initiate this Group I spawn. The eggs of Group I, by inspection of the modal peaks of the egg stages (Table 2), are apparently carried for 10-14 weeks before the larvae hatch into the plankton.

Growth rates for Group I young ($N = 14$) during the summer were described by: $Y = -6.04 + 0.76 (X)$. Where Y is the length of the shrimp in mm, -6.04 is the intercept, $+0.76$ is the slope of the regression line, and (X) is the week considered. Thus the growth of the young shrimp is approximately 0.76 mm per week. This equation holds for this group ($R^2 = 0.99$) until the shrimp are > 22 mm, or about 15-16 weeks after the shrimp leave the plankton. Growth rate of females then appears to accelerate so that by maturity (December-March) females are 8-10 mm larger than males (Fig. 7).

Group II shrimp hatch during mid- to late summer (Table 2) and are planktonic until December when they first appear in benthic samples. The young grow steadily until they reach spawning size from June to mid-August (Fig. 7). This spawning group consists of

newly mature females (8-10 mm larger than males) and some large females (Table 5), which apparently are repeat spawners from Group I. The eggs of this group are incubated 8-10 weeks (Table 2). Growth rate (January-June) of the young of Group II (N = 15) is described by: $Y = +7.79 + 0.95 (X)$, $R^2 = 0.99$, or about 0.95 mm of growth per week.

The smallest juvenile was 6.6 mm and the average size of the young leaving the plankton was 6.8-7.0 mm. Males are seldom larger than 40 mm and probably spawn once and die soon thereafter. Females seldom exceed 55 mm TL (Fig. 7) by which time they must be approximately 1-1/2 years old. The ratio of females to males was 1.35:1.00 (N = 4, 123), but there was great variation of the ratio between collections. It appears that Group I shrimp mature at a larger size than Group II (Fig. 7, Table 5). Differential size at maturity is likely caused by Group I's adult growth in the winter when temperature can effect the size at maturity.

C. franciscorum

The cycle of growth of the two species is similar. For C. franciscorum, the eggs of Group I hatch in the early spring (Table 6), develop into juveniles by May-July, and reach maturity in December (Fig. 11). The larger of these newly mature shrimp plus a few large females, probably the remains of the Group II females, begin

spawning in mid-December. The remainder reach maturity and spawn in February and March (Table 7, Fig. 11).

The young of Group II hatch during middle and late summer, and recruit to the population in December (Table 6, Fig. 11). Representatives of this recruitment (7-22 mm TL) are seldom seen and they are assumed to be out of the sampling area. The maturing adults reach spawning size in summer. The largest members of the new group, plus the repeat spawners from Group I, begin the spawning season near the end of May (Table 7, Fig. 11).

The incubation of eggs for Group I shrimp is not easily followed due to the lack of later stages in the samples (Table 6). It is probable that they hatch in 10-12 weeks and those of Group II hatch in 8-10 weeks. The young of Group I ($N = 16$) grow at a rate described by: $Y = -25.44 + 1.37 (X)$, with $R^2 = 0.99$. Because the young of Group II (7-20 mm TL) were not abundant within the sampling area, a growth equation was not possible. The smallest young was 6.8 mm and post-larval shrimp are probably between 7.0 to 7.4 mm TL when they enter the population.

Differential growth of males and females is also evident and probably occurs after sexually recognizable size has been achieved (Fig. 11). Females apparently are 8-12 mm larger than males at maturity. Males normally do not exceed 50-52 mm and females larger than 62 mm are rare (Fig. 11). As with C. nigricauda, it

appears that females of the pre-spring spawn mature at a larger size than those that spawn in summer (Table 7). The sex ratio for this species was 1.00:1.06 females to males ($N = 3,555$), though there was large variation between samples.

DISCUSSION

Because C. nigricauda and C. franciscorum occur naturally in Yaquina Bay, the response of these animals to their environment indicates the adaptive ability of the two species to co-inhabit the same body of water. The general response of adult C. nigricauda to the hydrographic influence appears to limit this species to the more oceanic environment of the bay (temperature 5.2-16.5 C and salinity 19.0-34.5 ppt (Figs. 4, 6). In the regression of temperature (T) on size, and salinity (S) on size, the trend was for smaller individuals of C. nigricauda to be found in the warmer and less saline water up-bay (Tables 1, 3). This concurs with the observations of Isreal (1936) who found the young of C. nigricauda in the shallow, low saline water of San Francisco Bay. He noted that with each stage of growth these shrimp generally went from shallow waters of low salinity to deeper more saline water.

Observations on similar species of Crangonids indicate that the smaller the young the better the osmoregulatory mechanism (Isreal 1936; Lloyd and Yonge 1947; Allen 1960, 1966). Broekema (1941, cited in Allen 1966) saw an apparent relationship between salinity and age of shrimp, where the optimum salinity for a 1-year-old was 18-19 ppt at 22 C and for a 2-year-old was 28-29 ppt at 22 C. This helps explain why the older animals do not penetrate as far up the estuary

as do the young, especially in the summer. Meredith (1952) felt that sexes and certain sizes congregate and move together, and Allen (1966) showed that young females penetrate further into the estuary than do males. The patterns of movement and the response to environmental changes indicate that both species in Yaquina Bay follow these patterns. It may be that the bulk of the adult population occurs at station No. 1 and oceanward and that the estuary serves as a nursery area on the fringe of the adult population.

C. franciscorum appears to be more versatile in its ability to cope with the physical changes within the bay than C. nigricauda (Isreal 1936). C. franciscorum is apparently more typical of a truly euryhaline species, withstanding ranges in temperature of 5.2-21.3 C and ranges in salinity of 0.2-34.4 ppt (Fig. 4, 9). Lloyd and Yonge (1947) and Allen (1966) state that for a euryhaline organism, the ability to withstand salinity is influenced by temperature, especially during early development. They point out further that experimental evidence indicates that osmoregulation proceeds more efficiently at high temperature and may even be inhibited at low temperatures. This explains why the young of C. franciscorum are found well up the estuary in large numbers, especially in the summer when high temperatures and low salinity abound (Fig. 4, 8). High temperature may also favor movement of young shrimp into more saline waters down bay.

The salinity optimum for C. franciscorum varies with the age of the animal in a fashion similar to that reported for C. vulgaris (Allen 1966). The young are evidently tolerant of brackish water, but with increasing age the salinity optimum shifts upward so that the larger individuals are found somewhat down-bay of the young (Figs. 8, 9). Except for spawning migrations, there is still the general trend away from high salinity water for this species.

The overall T-S gradient appears to separate the two Crangonid populations in Yaquina Bay. Within each distribution there is a subdistribution of age groups which separates adults from progeny. This overall distribution of the two species and the subdistributions tends to limit competition between and within species.

Along with the general migration in relation to salinity, there is a definite spawning migration for both species. Copulation and the subsequent release of eggs are reported to occur in brackish water (Lloyd and Yonge 1947). The reproductive migration starts with a movement of egg bearing females into deeper, highly saline water (Isreal 1936, Lloyd and Yonge 1947; Price 1962).

For C. nigricauda, the move to more oceanic water is evident in captures of ovigerous females at station No. 1 (Table 2) where the temperature ranges from 6.8-12.9 C and salinity ranges from 25.4-34.5 ppt (Fig. 4). Most spawning occurs in salinity ≥ 32 ppt, and is apparently followed by an out-bay migration to areas where the eggs

can hatch in high salinity water (Ehrenbaum 1890, cited in Isreal 1936; Lloyd and Yonge 1947). This out-migration, or "disappearance," is similar to that of C. allmani (Allen 1960) where the ovigerous females disappeared at the height of the breeding season when many were bearing A- and B-stage eggs. It seems unreasonable that these shrimp should die before the eggs matured fully; so the logical assumption is that these shrimp migrated from the estuary. A sampling program occurring at the time of this writing (July-August, 1973), located approximately 1 mi north of this estuary and sampling from 1-3 mi off-shore, captured numerous females with eggs in an advanced (C-D) stage plus a large percentage of females whose eggs had recently hatched (Appendix). This may also be the case with the ovigerous C. nigricauda of the early spring spawn, but the percentage of ovigerous females was small and the migration was not as evident.

The spawning migration of C. franciscorum is similar to C. nigricauda in that the general movement is to deeper, more saline water. Differences arise in the fact that the ovigerous females of this euryhaline shrimp do not require as high a salinity or as low a temperature regimen as do the ovigerous C. nigricauda. This is exemplified by the presence of the females at station No. 4 from May through July where salinities were 15-20 ppt and temperature was 13-19 C (Fig. 4, Table 7). It appears that the salinity range for

normal egg development can shift downward with increasing temperature, though as with C. vulgaris (Broekema 1941, cited in Allen 1966) normal egg development probably does not occur much below 15 ppt. Since adults commonly live at salinities less than 15 ppt, the ovigerous females tend to be concentrated where salinity is at its maximum.

A final movement from the estuary to cool, highly saline water probably occurs also for C. franciscorum. This "disappearance" is evidenced by the lack of females with C- and D-stage eggs which would be expected in February and August (Table 6).

The minimum size at maturity of 40 mm for female C. nigricauda in Yaquina Bay compares favorably with the 37 mm minimum found in San Francisco Bay by Isreal (1936). Meredith (1952) found variations in size at maturity at different localities for C. vulgaris which were probably related to temperature. Thus size at maturity may vary from year to year at the same location. A comparison of mature males was not possible because Isreal (1936) did not examine the testis of the shrimp he observed.

Various authors have noted an extended spawning season in Crangonids. Lloyd and Yonge (1947) and Meredith (1952) saw ovigerous females 10 months of the year, and Havinga (1930, cited in Lloyd and Yonge 1947) and Price (1962) saw ovigerous females 11 months of the year. Such extended spawning seasons were normally followed by a 1-2 month nonreproductive period (Giese 1959); however,

Isreal (1936) found ovigerous females during all months of the year. He concluded that in San Francisco Bay there is a single but extended spawning season with the main breeding period starting in March and extending through September. Meredith (1952) believed that breeding was continuous after maturity was reached and was probably controlled by the influence of temperature on the speed of development. Since the spawning season for C. nigricauda in Yaquina Bay is from December to mid-August followed by a 3-1/2 month nonreproductive period, it is probable that the variations between lengths of spawning seasons in California and Oregon are due to the cooler Oregon climate.

The two basic spawning peaks for C. nigricauda in Yaquina Bay were similar in composition and timing to that followed by C. vulgaris (Lloyd and Yonge 1947; Meredith 1952), C. septemspinosa (Price 1962), and C. allmani (Allen 1960). Meredith (1952) noted that females which spawned a second time did so only in the early summer. The composition and cycle of the spawning sequence was not recorded by Isreal (1936), but he did feel that some females might spawn a second time.

The "disappearance" of ovigerous females toward the end of the spawning period probably is due to a combination of the previously discussed spawning migration from the bay and mortality of large females. Meredith (1952) felt that the disappearance of large females (70-80 mm) in the summer was due to mortality and that the apparent

reappearance in August-September was due to growth of shrimp from 50-60 mm to 70 mm size. Allen (1960) agreed and also felt that males die before females, soon after copulation. With the shrimp in Yaquina Bay a high mortality of large females undoubtedly takes place at this time, but the appearance of some large individuals (> 50 mm TL) in November-December and the estimated adult growth rate (Fig. 7) indicates that a few of these females survive to spawn at least once more.

C. franciscorum matures at a smaller size (48 mm TL) in Yaquina Bay than it does in San Francisco Bay (53 mm TL) (Isreal 1936). Because size at maturity is probably related to temperature (Meredith 1952), the probable conclusion is that temperatures in San Francisco Bay are closer to the optimum for C. nigricauda while those in Yaquina Bay must be closer to the optimum for C. franciscorum.

The hatching of eggs at a time when the larvae will utilize the spring and fall plankton maxima is apparent in the cycle of growth for both species in Yaquina Bay. Allen, in his 1966 study of 13 caridean shrimp observed that no species laid eggs much after the end of September. He observed an ensuing gap of 8-10 weeks before breeding commenced again. This period of non-breeding allowed the utilization of the spring and autumn plankton maxima by the larvae. It is possible that this resting phase is cued by diminishing light intensity in the early fall.

Both species exhibit an apparent shorter egg incubation period for Group II than for Group I segments of the population which is likely temperature dependent. Studies on comparable species of Crangonids indicate similar variations in the length of incubation. Havinga (1930, cited in Allen 1960), Meredith (1952), and Allen (1960) saw the incubation period halved between winter and summer spawners (9-12 weeks in winter to 4-6 weeks in summer).

An additional parameter which could shorten the summer incubation period would be high salinity. Broekema (1941, cited in Allen 1960) noted that low salinity retards egg development, incubation requiring twice as long at 16 ppt than at 35 ppt. If this is the case, estimates of the time until hatching for C. franciscorum could be overestimated due to incubation in areas of low salinity but high temperature in the summer hatch. Laboratory rearing of these shrimp would at least aid in the interpretation of the time required for incubation.

There is a general similarity of the cycle of growth, maturity, and mortality of the two species. Both species apparently reach maturity at the end of one year, and at least a portion of the females spawn either as repeat spawners in early summer or survive the fall resting phase (Giese 1959) and initiate the pre-spring spawning. I doubt that any female shrimp of either species live much longer than a year and a half, or spawn more than twice. Nor do I believe males to live longer than one year, since large males disappear after each

breeding season and are continually replaced by incoming age classes (Figs. 7, 11). It appears that Allen (1960) was correct in assuming that males died soon after copulation.

Other species of Crangonids apparently live longer than either C. nigricauda or C. franciscorum. C. septemspinosa (Price 1962) reaches 23 mm in its first year, 42 mm in its second year, and 61 mm in the third year. Price thought females lived more than three years and males more than two. His estimates of age came from growth equations for the adults; but his length-frequency histogram implies a growth similar to that of the Yaquina Bay shrimp. Allen (1960, 1966) believed that most Caridean shrimp reach maturity within 12 months of hatching, but that most C. allmani died in their third year with a few living into the fourth. A similar 3-4 years of life was noted in C. vulgaris (Lloyd and Yonge 1947). Undoubtedly the major problem in deciphering the growth of Crangon arises from the fact that the females do not spawn synchronously, so that the age classes are not exceptionally clear. This problem is compounded in length-frequency histograms by the incoming age classes which obscure the slow growing older shrimp. A possible use of the shrimp tagging method devised by Tiews (1965) might aid in determining age and in following migrations.

Growth of young shrimp showed variations between species and between spawning groups. Since C. franciscorum attains the greatest size of either species and both reach maturity in a single year, it is

reasonable that this species would have a faster growth rate.

The young of the two spawning groups poses a different question for C. nigricauda. The growth rate of the young in the warmer summer season (Group I) was not faster than that for the young which grow in the winter (Group II). The reverse was true and was contrary to the findings of Lloyd and Yonge (1947) and Meredith (1952). Perhaps the anticipated increases in growth rate with higher temperatures are cancelled by high energy requirements for physiological adaption and further retarded by a metabolism adapted to lower temperatures for this species.

All species of Crangonids (Lloyd and Yonge 1947; Meredith 1952; Allen 1960; Price 1962) exhibit a differential growth rate between large females and males. The size at which the females increased their growth rate appears to be a function of the age at maturity for a particular population. C. nigricauda and C. franciscorum in both San Francisco Bay (Isreal 1936) and Yaquina Bay exhibit differential growth at an early age (4-5 months after they leave the plankton).

Allen (1960) observed no significant differences in the molting frequency between males and females, except that egg bearing females do not molt. Nor was a length increase reported at the molt just prior to egg laying (Lloyd and Yonge 1947). Therefore, the large differences in maximum size is due to a faster growth rate of females and is accentuated by the death of males after copulation and the survival

of larger, older females following the spring and fall spawning seasons.

The sex ratio of the Crangonid population varies greatly from sample to sample, but will average in favor of the females (Lloyd and Yonge 1947; Meredith 1952; Price 1962). This must be due to the early death of males and the fact that some females live to spawn a second time. In the case of C. franciscorum where the ratio is approximately 1:1, I feel the reason must be due to the limits of the sampling area. Isreal (1936) reported an imbalance of the sex ratio for C. franciscorum in favor of females during breeding season and in favor of males prior to breeding season. In a pattern comparable to C. vulgaris and C. allmani (Allen 1966), the shrimp of Yaquina Bay kept a close male:female ratio prior to and during the breeding season. This type of close sex ratio is what one would expect from shrimp which lay more than one brood and exhibit nonsynchronous spawning.

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APPENDIX

Appendix Table 1. Basic meristic information and date and location of capture of Pandalus danae (Stimpson) in Yaquina Bay, Oregon, 1970-72.

Date	Station No.	Length (TL mm)*	Dorsal rostral spines	Ventral rostral spines	Tip of rostrum
3/ 1/71	1	45.2	11	**	**
		43.6	10	6	trifid
		37.4	10	6	trifid
3/29/71	1	39.6	11	7	**
		38.4	10	6	trifid
		19.6	10	**	**
6/ 6/71	3	15.8	10	6	trifid
		16.2	10	6	trifid
		22.0	9	6	trifid
6/18/71	1	19.6	10	**	**
		14.8	12	6	trifid
		14.6	11	6	**
		13.4	10	**	**
		14.4	12	6	trifid
		20.2	11	6	trifid
		19.6	10	5	trifid
6/18/71	3	19.4	11	6	trifid
		18.2	11	6	trifid
		19.4	10	5	trifid
		14.2	10	7	trifid
7/ 2/71	2	25.0	10	7	trifid
		24.4	11	6	trifid
		27.8	10	**	**
		26.2	10	7	trifid
		25.4	10	7	trifid
		24.6	**	**	**
		23.6	11	6	trifid
		23.0	10	7	trifid
		19.8	10	6	trifid
		19.0	**	**	**
		18.2	12	6	trifid
		17.8	10	6	trifid
		18.4	11	6	trifid
		16.8	10	7	trifid
		16.6	12	7	trifid
7/ 2/71	3	25.2	10	6	trifid
		23.6	12	7	trifid
		26.0	10	**	**

(Continued on next page)

Appendix Table 1. (Continued)

Date	Station No.	Length (TL mm)*	Dorsal rostral spines	Ventral rostral spines	Tip of rostrum
7/16/71	3	31.2	10	6	trifid
		31.2	10	6	trifid
		30.6	10	6	trifid
		32.0	11	6	trifid
		29.2	11	6	**
		26.6	10	7	trifid
		27.0	10	7	trifid
		28.4	12	7	trifid
		27.2	12	**	**
		23.2	12	6	trifid
		15.0	**	**	**
7/30/71	1	29.0	8	6	trifid
7/30/71	2	25.2	11	6	trifid
		24.8	9	6	trifid
		21.8	10	6	trifid
		20.2	12	7	trifid
7/30/71	3	35.2	11	6	trifid
		32.8	10	6	trifid
		36.4	10	7	trifid
		38.0	9	6	trifid
		35.6	10	6	trifid
		33.0	9	6	trifid
		32.4	11	6	**
		32.8	10	6	trifid
		31.4	11	7	trifid
		32.2	10	7	trifid
		33.2	12	6	**
		28.8	11	7	**
		29.0	9	6	trifid
		31.2	10	7	trifid
		27.4	9	7	trifid
		33.4	12	7	trifid
		27.8	10	6	trifid
		29.8	10	**	**
		25.6	11	7	trifid
		18.4	13	6	trifid
		21.2	8	6	bifid
8/13/71	1	33.6	11	6	trifid
		27.6	11	6	trifid
		30.6	11	**	**

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Appendix Table 1. (Continued)

Date	Station No.	Length (TL mm)*	Dorsal rostral spines	Ventral rostral spines	Tip of rostrum
8/13/71	1	20.4	10	6	trifid
		17.8	12	8	trifid
8/13/71	2	40.4	10	7	trifid
		39.2	8	6	trifid
		34.2	10	6	trifid
		33.2	10	7	trifid
		31.4	10	6	trifid
		31.0	11	6	trifid
		29.8	10	6	trifid
		30.0	12	6	trifid
		26.0	9	**	**
		27.2	11	6	trifid
		26.4	12	6	trifid
		21.2	10	7	trifid
		26.0	11	6	trifid
		20.0	8	7	trifid
		18.6	11	7	trifid
		15.6	11	6	trifid
		14.6	10	6	trifid
		38.8	11	7	trifid
		35.4	**	**	**
8/13/71	3	34.0	9	7	trifid
		37.0	11	6	trifid
		34.6	11	6	trifid
		35.6	11	7	trifid
		31.8	11	6	trifid
		31.8	12	6	trifid
		30.6	10	6	trifid
		30.4	9	**	**
		29.4	11	7	trifid
		29.2	**	**	**
		31.4	9	6	trifid
		24.8	11	6	bifid
		26.0	11	7	simple
		23.0	11	6	trifid
		21.2	11	**	**
		17.2	10	**	**
8/27/71	1	41.0	11	7	trifid
		39.4	12	7	trifid
		39.0	11	6	trifid
		37.6	10	6	trifid

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Appendix Table 1. (Continued)

Date	Station No.	Length (TL mm)*	Dorsal rostral spines	Ventral rostral spines	Tip of rostrum
8/27/71	1	37.6	11	7	trifid
		36.6	12	6	**
		35.6	11	6	trifid
		34.4	13	7	trifid
		34.6	12	**	**
		33.4	**	**	**
		32.6	11	**	**
		30.6	13	6	trifid
		33.4	11	6	trifid
		29.4	10	7	trifid
		30.4	11	7	trifid
		28.0	9	**	**
		28.0	10	7	trifid
		37.8	**	**	**
		38.4	11	6	trifid
8/27/71	2	38.2	10	6	trifid
		44.0	10	**	**
		35.6	10	7	trifid
		33.0	11	6	trifid
		36.8	11	6	trifid
		32.0	11	7	trifid
		28.6	12	7	trifid
		22.0	10	6	trifid
		25.2	**	**	**
		38.2	10	6	trifid
		33.0	13	7	trifid
		29.2	11	6	trifid
		21.6	**	**	**
		22.0	**	**	**
		41.0	11	6	**
8/27/71	3	40.4	10	**	**
		40.8	11	7	trifid
9/10/71	1	36.8	11	7	trifid
		38.2	**	**	**
		27.6	11	6	trifid
		27.8	10	6	**
		27.0	11	7	trifid
9/10/71	2	18.4	11	7	trifid
9/10/71	3	44.4	11	6	trifid
		45.6	10	6	trifid

(Continued on next page)

Appendix Table 1. (Continued)

Date	Station No.	Length (TL mm)*	Dorsal rostral spines	Ventral rostral spines	Tip of rostrum
9/10/71	3	40.2	9	6	**
		40.6	**	**	**
		46.4	9	**	**
		34.4	10	6	**
		43.0	9	7	trifid
		36.4	11	6	trifid
		36.4	10	6	trifid
		33.2	10	6	trifid
		29.0	11	7	trifid
		28.0	**	**	**
		22.2	10	6	trifid
9/24/71	1	46.0	9	7	trifid
		48.8	11	6	trifid
		43.0	11	7	trifid
		39.6	11	7	trifid
		38.0	10	6	trifid
		34.2	11	7	trifid
		33.0	10	**	**
		27.6	11	7	trifid
10 / 8/71	1	55.8	**	**	**
		46.6	12	6	**
		50.4	**	**	**
		47.6	11	6	trifid
		53.6	10	7	**
		43.6	11	6	trifid
		48.0	11	**	**
		41.6	11	7	trifid
		41.6	10	6	trifid
		46.4	10	**	**
		40.0	9	6	**
		41.8	11	7	trifid
		41.2	10	6	trifid
		49.4	**	**	**
		40.2	10	6	trifid
		37.4	11	6	trifid
		39.0	10	6	trifid
		47.6	11	6	trifid
		45.4	11	6	trifid
		40.4	11	7	trifid
		38.0	11	6	trifid

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Appendix Table 1. (Continued)

Date	Station No.	Length* (TL mm)	Dorsal rostral spines	Ventral rostral spines	Tip of rostrum
10 / 8 / 71	1	40.4	10	6	trifid
		33.2	11	6	**
		31.0	11	6	trifid
		34.2	11	**	**
		34.0	11	7	trifid
		33.2	10	7	trifid
		31.6	9	6	trifid
		27.4	10	7	trifid
		43.4	**	**	**
10 / 8 / 71	2	43.4	**	**	**
10 / 22 / 71	1	44.8	10	7	trifid
		41.4	9	7	trifid
		41.8	11	6	trifid
10 / 22 / 71	3	38.0	11	6	trifid
12 / 17 / 71	1	49.6	9	6	trifid
		45.2	12	7	trifid
		42.6	11	6	trifid
		39.4	12	6	trifid
		50.2	12	6	trifid
12 / 30 / 71	1	46.6	10	6	trifid
		43.8	11	**	**
		44.4	11	7	trifid
		40.0	10	6	trifid
		39.8	11	6	trifid
		38.2	10	7	**
		39.6	10	6	trifid
		37.2	11	6	trifid
		24.0	11	6	trifid
		47.4	10	6	trifid
		44.2	11	6	trifid
		40.4	11	6	trifid
		44.6	10	7	trifid
		43.6	10	6	bifid
		42.4	**	**	**
2 / 25 / 72	1	42.4	**	**	**
		36.8	10	7	bifid

* Total length was measured from the posterior edge of the orbit to the tip of the telson.

** Broken rostrum

Appendix Table 2. Basic meristic information and date and location of capture of Pandalus platyceros (Brandt) in Yaquina Bay, Oregon, 1970-72.

Date	Station No.	Length (TL mm)*	Dorsal rostral spines	Ventral rostral spines	Tip of rostrum
6/18/71	1	13.6	13	**	**
		10.8	15	5	a
7/ 2/71	3	24.4	**	**	**
8/27/71	2	38.0	16	6	a
11/19/71	3	79.2	15	7	a

* Total length was measured from the posterior edge of the orbit to the tip of the telson.

** Broken rostrum

^a Acute tip with single spine near dorsal tip

Appendix Table 3. Basic meristic information and date and location of capture of Heptacarpus brevirostris (Dana) in Yaquina Bay, Oregon, 1970-72.

Date	Station No.	Length (TL mm) *	Dorsal rostral spines
12/21/70	3	15.2	4
1/ 4/71	2	14.6	4
1/11/71	3	16.2	4
		14.6	4
1/18/71	1	25.6	4
1/18/71	3	18.6	4
		17.2	4
3/ 1/71	1	19.2	4
		17.6	4
3/29/71	1	17.8	4
		12.8	1
6/18/71	1	10.0	4
7/ 2/71	1	6.4	3
		33.0	4
7/ 2/71	2	11.4	5
		11.8	4
7/30/71	3	21.4	4
		13.0	4
8/13/71	1	18.8	4
		11.2	4
		7.8	4
8/13/71	2	21.2	4
		15.8	4
8/13/71	3	23.4	4
		22.8	4
		24.2	4
		22.2	4
		21.0	4
		22.6	4
		21.4	4
		21.0	4
		21.4	4
		18.8	4
		19.0	4
		18.6	4
		20.0	5
		17.0	4
		16.4	4
		15.8	4

(Continued on next page)

Appendix Table 3. (Continued)

Date	Station No.	Length (TL mm) *	Dorsal rostral spines
8/13/71	4	21.6	4
8/27/71	2	18.0	4
		22.4	4
		27.2	4
8/27/71	3	24.8	4
		29.8	4
		25.2	4
		21.8	5
		22.0	4
		21.8	4
		20.2	5
		19.4	4
		20.2	4
		18.4	4
		18.8	4
		15.0	4
		14.4	4
		12.2	4
9/10/71	1	20.8	4
		17.8	4
		18.0	4
9/10/71	2	19.6	4
		16.8	4
		13.2	4
9/10/71	3	23.2	4
		22.6	4
		20.8	4
		20.0	4
		14.8	3
		14.2	3
		13.4	4
9/10/71	4	20.0	4
9/24/71	1	20.0	4
9/24/71	2	27.2	4
9/24/71	3	24.8	4
10/ 8/71	1	19.8	4
10/ 8/71	2	25.6	4
10/ 8/71	3	27.2	4
		17.0	4
		17.2	4
10/22/71	1	20.8	4

(Continued on next page)

Appendix Table 3. (Continued)

Date	Station No.	Length (TL mm) *	Dorsal rostral spines
10/22/71	1	21.8	4
		11.2	4
		9.6	4
11/ 6/71	1	30.4	4
		23.6	4
		25.4	4
		23.4	4
11/ 6/71	3	17.8	4
11/19/71	1	27.6	4
		29.6	4
		26.0	4
		24.6	5
		25.2	4
		22.0	4
		23.0	4
		21.2	4
11/19/71	2	28.8	4
		28.4	4
		23.4	4
12/17/71	1	17.8	4
		18.6	4
		15.2	4
12/17/71	2	23.8	4
		11.4	4
12/30/71	1	28.0	4
		22.2	4
		20.0	4
		16.8	4
		17.2	5
		16.2	4
		31.8	4
		33.2	5
		27.2	4
1/14/72	1	14.4	4
		12.4	4
1/28/72	1	30.4	4
		26.6	4
2/11/72	1	35.6	4

(Continued on next page)

Appendix Table 3. (Continued)

Date	Station No.	Length (TL mm) *	Dorsal rostral spines
2/11/72	1	34.0	4
		28.2	4
		19.4	4
		8.6	4
2/25/72	1	37.0	4
		32.0	4
2/25/72	2	12.8	4

* Total length was measured from the posterior edge of the orbit to the tip of the telson.

Appendix Table 4. Basic meristic information and date and location of capture of Heptacarpus sitchensis (Brandt) in Yaquina Bay, Oregon, 1970-72.

Date	Station No.	Length (TL * mm)	Dorsal rostral spines	Ventral rostral spines	Date	Station No.	Length (TL * mm)	Dorsal rostral spines	Ventral rostral spines
12/21/70	3	16.2	6	3	1/11/71	3	15.2	7	2
		17.8	**	**	(cont'd)		15.0	7	3
		16.0	6	4			15.4	6	3
		16.4	6	3			14.4	6	4
		15.4	6	2			14.4	7	3
		16.0	7	3			14.0	7	3
		14.6	3	1			12.8	7	3
		13.4	7	3			12.2	6	2
		13.2	5	3			11.6	7	3
		14.0	6	3			11.2	7	3
		13.8	6	3			12.2	5	3
		13.2	6	2			10.6	7	3
		11.6	7	4			10.8	5	**
		12.6	7	3			11.8	7	3
		11.4	7	3			10.8	7	3
		11.0	6	3			9.6	7	3
		10.6	**	**			9.2	5	2
		10.2	6	3			7.0	5	2
		10.6	7	3	1/18/71	2	16.6	6	3
		11.0	6	3			15.4	6	3
		11.2	5	3			13.8	6	3
		10.8	6	3			11.4	7	2
		10.0	7	3			8.0	6	2
		9.6	6	3	1/18/71	3	16.6	6	3
		10.2	7	2			15.0	6	3
		9.6	6	3			12.2	6	3
		9.6	6	3			10.8	6	3
		8.8	6	2	1/25/71	2	15.8	7	4
		9.6	7	3	3/ 1/71	2	12.4	6	3
		9.4	6	3			11.8	6	3
		8.4	7	2			12.2	6	3
		7.8	7	2			9.0	5	3
		8.0	6	2	3/ 1/71	3	14.8	6	3
		7.4	6	2			14.8	6	3
1/ 4/71	2	14.6	7	4			13.6	6	2
1/11/71	2	18.0	7	3			10.0	6	3
		13.2	6	3	3/15/71	2	18.8	5	3
		10.0	7	2			15.6	7	3
1/11/71	3	19.0	7	3			15.4	6	4
		17.0	6	3			13.4	7	4
		16.4	7	4			12.6	6	3
		15.4	6	3			11.2	6	4
		16.2	7	2			9.8	7	3
		15.2	7	2	3/15/71	3	19.0	7	4
		16.2	7	2			19.4	7	2

(Continued on next page)

Appendix Table 4. (Continued)

Date	Station No.	Length (TL * mm)	Dorsal rostral spines	Ventral rostral spines	Date	Station No.	Length (TL * mm)	Dorsal rostral spines	Ventral rostral spines
3/15/71	3	19.8	7	3	4/12/71	3	13.4	7	2
(cont'd)		18.8	6	4	(cont'd)		12.6	6	3
		17.4	6	3			13.4	6	2
		16.6	6	3			12.0	7	3
		17.4	6	4			12.8	6	2
		16.2	7	2			11.2	6	3
		17.0	6	3			12.0	6	3
		16.4	7	3			11.6	6	3
		16.4	6	3			11.6	6	3
		15.2	6	3			11.4	7	3
		13.6	6	**			11.6	6	3
		11.2	6	2			12.0	6	3
		11.0	7	2			9.8	6	1
		11.6	7	3			9.8	**	**
		11.2	6	3	5/ 7/71	3	13.0	7	3
		11.4	7	3			11.6	6	3
		10.6	7	3			12.6	6	2
		11.0	6	3			12.4	7	3
		9.6	6	2			12.6	6	3
3/29/71	1	19.6	7	3			11.4	6	3
		19.4	7	3			13.0	6	3
		12.6	6	2	5/ 7/71	4	12.8	6	2
3/29/71	3	18.6	6	4	5/21/71	3	11.4	6	2
		20.4	6	3	6/ 6/71	3	18.0	7	3
		19.4	6	3			19.4	6	3
		19.2	7	3			19.2	**	**
		19.0	7	4			19.6	6	3
		15.2	6	3			18.4	5	3
		13.6	7	3			17.6	5	4
		15.6	6	3			17.0	6	2
		12.0	6	3			14.0	5	2
		11.2	**	**			11.4	7	3
		12.0	7	4	6/18/71	2	12.4	5	3
		10.6	7	3	7/ 2/71	2	21.6	6	3
		10.0	6	3			20.6	6	2
4/12/71	2	12.8	**	**			20.6	6	4
4/12/71	3	21.2	7	3			18.8	6	2
		19.2	7	3	7/ 2/71	3	13.6	7	4
		20.4	6	4	7/30/71	3	18.6	6	3
		18.6	6	3	8/13/71	3	18.8	6	2
		13.8	7	3			18.6	7	4
		14.8	7	4	8/27/71	3	22.0	6	2
		13.4	6	3			10.6	7	3
		13.0	6	3	9/24/71	3	11.4	7	4
		13.4	6	3			10.4	7	3
		13.0	6	3	10/ 8/71	3	13.4	6	3

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Appendix Table 4. (Continued)

Date	Station No.	Length (TL * mm)	Dorsal rostral spines	Ventral rostral spines	Date	Station No.	Length (TL * mm)	Dorsal rostral spines	Ventral rostral spines
11/ 6/71	1	18.0	6	3	12/ 3/71	3	15.6	6	3
		14.8	6	3	(cont'd)		17.8	7	3
		12.8	6	3			18.2	6	3
11/ 6/71	2	13.4	6	3			17.8	6	3
11/ 6/71	3	16.2	6	**			15.4	5	3
		15.6	6	3			15.0	6	3
		14.6	6	4			15.0	6	4
		14.4	7	3			15.8	6	3
		14.8	6	3			16.0	6	3
		11.8	6	2			16.2	6	2
		12.4	6	4			14.4	**	**
		12.0	6	3			16.6	7	4
11/ 6/71	4	14.8	6	3			15.2	6	4
11/19/71	2	13.2	6	3			14.6	**	**
		13.0	6	3			14.0	7	3
		10.8	7	3			14.0	7	4
		11.0	7	3			14.6	6	2
11/19/71	3	17.4	5	3			15.4	7	3
		14.8	6	3			15.0	6	3
		18.2	6	3			14.4	6	3
		15.8	6	3			13.0	6	3
		16.6	6	3			15.0	6	3
		16.6	6	3			15.2	6	4
		15.8	7	3			12.4	6	3
		16.4	6	3			13.6	7	3
		16.4	**	**			12.4	7	3
		15.2	7	3			14.0	6	4
		15.0	6	4			12.0	6	3
		15.2	6	3			14.0	6	3
		15.6	7	4			12.8	7	3
		13.8	7	4			12.2	6	3
		13.8	6	3			12.4	**	**
		14.0	7	3			13.4	6	**
		13.6	8	4			11.2	6	3
		12.4	6	4			11.4	6	3
		12.6	6	3			11.4	6	4
		11.0	6	3			11.4	7	3
		12.2	7	4			10.6	6	3
		11.6	6	3			11.4	6	3
		10.8	6	2			12.4	6	3
		11.0	6	3			10.6	7	3
		11.4	6	3			10.8	7	3
		10.8	6	4			12.0	7	3
		10.4	**	**	12/17/71	2	21.8	6	3
12/ 3/71	3	19.8	6	3			18.6	6	3
		21.4	7	**			19.8	6	4
		16.6	6	3			18.6	**	**

(Continued on next page)

Appendix Table 4. (Continued)

Date	Station No.	Length (TL * mm)	Dorsal rostral spines	Ventral rostral spines	Date	Station No.	Length (TL * mm)	Dorsal rostral spines	Ventral rostral spines
12/17/71	2	17.0	6	4	12/17/71	2	11.2	**	**
(cont'd)		18.6	6	5	(cont'd)		10.6	6	3
		19.2	6	4			11.2	6	3
		17.2	5	3			9.0	6	3
		18.4	6	3			10.0	6	4
		18.6	7	3			10.0	6	3
		17.0	6	3			11.4	7	4
		16.6	7	3			11.8	7	3
		17.0	6	4			8.8	6	2
		17.6	7	3			7.4	6	1
		16.4	7	3	12/30/71	1	16.0	6	5
		16.8	7	3	12/30/71	2	20.8	6	3
		16.0	7	3			18.0	6	2
		15.8	6	3			20.6	5	3
		16.4	6	3			20.4	7	3
		17.0	6	3			18.6	7	3
		16.8	6	3			20.8	7	2
		15.0	6	3			18.8	6	3
		16.0	6	4			18.0	5	3
		15.2	5	3			16.2	6	2
		15.6	7	3			16.8	6	2
		15.4	7	4			16.2	7	2
		14.8	6	3			18.0	6	3
		15.2	6	4			15.2	6	2
		14.6	7	4			14.6	6	3
		14.2	7	3			13.8	6	2
		13.4	6	3			15.2	7	2
		14.4	7	3			14.8	7	4
		13.6	6	3			12.6	6	2
		13.6	7	3			10.8	7	3
		14.4	7	3			10.0	6	3
		14.4	5	3	12/30/71	3	14.4	7	2
		10.6	6	4			13.2	6	3
		13.4	7	3			16.2	6	3
		13.2	7	4			14.4	6	3
		13.0	6	3			14.4	6	3
		12.6	6	3			13.8	5	3
		12.4	7	3			15.0	6	3
		12.0	6	3			14.6	7	2
		11.8	6	3			14.6	5	3
		12.0	5	3			14.2	7	2
		11.4	5	2			12.6	7	3
		11.2	6	4			13.6	6	3
		12.4	6	4			13.8	7	2
		11.0	7	3			14.0	7	3
		12.0	6	4			13.8	7	3
							14.2	6	3

(Continued on next page)

Appendix Table 4. (Continued)

Date	Station No.	Length (TL * mm)	Dorsal rostral spines	Ventral rostral spines	Date	Station No.	Length (TL * mm)	Dorsal rostral spines	Ventral rostral spines
12/30/71 (cont'd)	3	13.8	6	3	12/30/71 (cont'd)	3	16.8	6	3
		14.0	5	2			18.8	7	4
		13.6	7	3			16.6	8	4
		14.0	6	2			16.8	6	3
		14.6	7	3			17.2	6	3
		13.2	**	**			19.0	6	3
		12.8	6	3			16.8	7	4
		14.0	6	3			15.4	7	4
		11.8	7	3			15.6	6	3
		13.6	6	3			18.2	6	3
		12.6	6	4			18.2	7	3
		13.0	7	3			15.8	6	3
		12.2	7	3			16.4	6	3
		12.2	6	4			15.8	7	3
		12.8	6	**			16.6	6	4
		12.4	7	3			15.8	7	3
		13.4	6	4			15.8	**	**
		12.2	7	3			16.0	7	3
		13.6	7	3			14.8	6	3
		11.4	7	3			16.8	6	3
		11.2	6	3			16.0	5	4
		12.0	**	**			16.0	6	2
		12.4	6	3			15.6	6	3
		12.2	6	3			15.8	6	3
		12.6	6	3			14.0	6	5
		12.4	7	3			15.0	7	4
		11.4	6	3			15.6	6	3
		12.8	6	3			14.2	6	**
		12.2	6	3			14.0	6	**
		12.0	7	3			11.8	7	3
		18.4	6	3			11.6	6	3
		19.8	6	4			11.8	6	3
		19.4	6	2			12.0	7	3
		18.6	6	4			11.6	7	3
		17.8	5	5			11.2	8	3
		17.2	6	4			10.6	6	2
		16.8	6	5			11.6	6	3
		17.2	7	4			11.2	6	3
		18.4	6	3			11.2	7	4
		19.6	6	3			11.0	6	3
		19.4	5	2			10.8	6	2
		17.2	6	4			8.6	6	3
		17.4	6	3			9.8	6	2
		16.8	6	3			11.4	**	**
		17.2	6	3			9.0	6	3
		16.2	7	4			9.8	6	3

(Continued on next page)

Appendix Table 4. (Continued)

Date	Station No.	Length (TL * mm)	Dorsal rostral spines	Ventral rostral spines	Date	Station No.	Length (TL * mm)	Dorsal rostral spines	Ventral rostral spines
12/30/71	3	10.4	6	3	2/11/72	2	15.0	7	3
(cont'd)		9.8	6	2	(cont'd)		14.6	7	3
		9.2	6	2			12.8	7	3
		9.6	6	3			12.2	**	**
		8.8	6	3			11.8	7	3
		7.6	5	2			14.0	6	4
		7.0	5	2			13.0	7	2
		5.4	3				12.0	6	2
1/14/72	1	19.0	7	4			12.6	6	**
		18.6	6	3			11.6	6	4
		16.8	7	5			11.2	7	3
		17.6	7	3			11.4	5	2
		17.0	6	3			12.0	6	2
		16.6	7	4			11.6	7	3
		16.8	6	3			11.0	6	3
		16.8	6	3			10.4	6	3
		16.0	6	2			11.2	6	3
		14.6	7	4	2/25/72	2	17.4	7	3
		14.6	6	3			18.4	7	3
		12.8	6	4			15.0	6	2
		14.8	**	**			14.2	7	3
		14.6	7	3			16.2	6	3
		15.2	7	3			15.6	7	3
		12.8	6	3			15.4	6	2
		12.2	7	3			13.6	6	3
		12.4	5	3			11.6	7	3
		11.6	7	3			12.4	6	3
		10.8	7	3			13.0	6	3
		9.2	6	3			11.6	7	3
1/14/72	2	18.6	7	3	2/25/72	3	18.4	6	3
		14.8	7	3			20.8	6	3
1/28/72	1	18.0	6	3			18.6	6	3
1/28/72	2	16.8	6	3			20.0	**	**
		13.8	6	4			19.0	6	3
1/28/72	3	19.0	7	4			19.8	6	3
		16.0	6	3			19.2	6	3
2/11/72	2	17.8	6	4			18.4	6	3
		17.6	6	4			16.8	6	3
		16.8	7	3			12.4	6	2
		16.4	6	4			10.4	6	2
		18.0	6	4					
		15.4	6	4					
		16.2	7	3					
		14.4	7	3					
		14.8	6	3					

*Total length was measured from the posterior edge of the orbit to the tip of the telson.

**Broken rostrum.

Appendix Table 5. Length (mm TL), sex, condition of females, and date of capture of *Crangon nigricauda* from three locations off Moolack Beach (3 mi. north of Yaquina Bay), Oregon, 1973.

1 Mile Offshore		2 Miles Offshore		3 Miles Offshore	
Length	Condition ¹	Length	Condition ¹	Length	Condition ¹
Female (24:VII:73)		Female (24:VII:73)		Female (24:VII:73)	
60.5	E	45.6	O	65.6	C
(2:VIII:73)		49.4	O	58.0	E
57.6	O	Male		60.2	E
44.3	O	(24:VII:73)		56.4	D
44.6	B	24.4		54.6	E
46.2	A	24.5		45.6	E
41.2	O	25.0		60.0	E
41.9	B	22.4		53.4	E
45.3	B	37.2		47.5	O
44.2	A			52.7	E
40.7	O			51.6	E
38.0	O			48.2	E
Male				56.4	E
(24:VII:73)				58.7	E
29.0				50.8	B
32.5				46.4	O
22.5				52.8	B
23.7				44.4	E
23.2				43.8	E
34.5				54.7	E
33.8				52.0	C
(2:VIII:73)				50.5	C
32.1				50.5	E
32.8				43.8	E
32.0				58.3	D
28.0				49.6	E
				42.8	E
				56.0	E
				49.0	C
				57.2	E
				51.2	E
				44.8	E
				52.8	E
				57.4	E
				45.8	E
				50.2	E
				41.2	E
				46.4	E
				45.2	E
				40.4	E
				43.3	E
				43.1	E
				42.8	E
				Male	
				(24:VII:73)	
				23.1	
				29.6	
				21.8	

¹ Condition A, B, C, D described in text Figure 3; Condition E = spawned female with remains of eggs; condition O = premolt (either pre- or post-spawning condition).

Appendix Table 6. Date, location of capture¹, and length (mm TL) of female Crangon franciscorum infected by the isopod Argeia pugettensis in Yaquina Bay, Oregon, 1970-72.

Date	Sampling Station	Length	Date	Sampling Station	Length
1 / 4 / 71	2	45.4	4 / 12 / 71	2	43.8
		42.8			51.8
		44.2			48.6
		41.6	5 / 7 / 71	3	51.2
		37.8			50.8
		39.2	5 / 21 / 71	1	54.4
		42.2	6 / 18 / 71	2	51.6
		40.6			50.8
1 / 18 / 71	2	41.0	12 / 3 / 71	3	42.8
		44.0	12 / 17 / 71	3	53.4
		39.6			47.6
		39.4			41.4
		42.0	12 / 30 / 71	2	42.4
		43.4			45.2
1 / 18 / 71	3	41.6			49.8
		36.8			43.0
		47.2	1 / 14 / 72	3	33.8
1 / 25 / 71	2	43.8			46.6
1 / 25 / 71	3	46.2			31.4
3 / 1 / 71	2	49.6			40.4
		50.2	1 / 28 / 72	1	53.4
		33.8	1 / 28 / 72	3	45.4
3 / 1 / 71	3	49.4			50.2
		45.8	2 / 11 / 72	2	54.4
3 / 15 / 71	2	45.0			47.4
		37.6	2 / 25 / 72	2	46.8
3 / 15 / 71	3	58.0			46.0
		42.0			
3 / 15 / 71	4	39.8			
		46.0			
3 / 29 / 71	2	51.8			
		41.8			
3 / 29 / 71	4	42.6			
		39.0			
4 / 12 / 71	2	48.2			
		43.4			
		40.8			
		47.4			

¹ Sampling stations Nos. 1-4 (Fig. 1).