OBSERVATIONS ON THE LARVAL HATCHING SUCCESS OF DUNGENESS CRAB, *CANCER MAGISTER*, FROM THE SAN FRANCISCO AND EUREKA-CRESCENT CITY REGION

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ABSTRACT

Ovigerous Dungeness crabs were collected from the San Francisco and Eureka-Crescent City regions and maintained at the Department's Marine Culture Laboratory near Monterey. Hatching success, expressed as viable larvae released, was measured and compared by region. Larval counts were made from 15 Dungeness crabs, 5 from the San Francisco region, 7 from the Eureka-Crescent City area and 3 of unknown origin. Mean hatching success exceeded 80% in the San Francisco region, and averaged more than 90% in the Eureka-Crescent City area. However, a Student's t-Test showed this difference in hatching success was not significant.

TABLE OF CONTENTS

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INTRODUCTION

The decline in the San Francisco region of the Dungeness crab, *Cancer magister*, fishery in recent years has been of major concern to scientists, fishermen and the general public alike. Yet, until 1974 there had been almost no support to launch a major study to identify possible causative factors.

Crab investigations for the most part have been limited to population dynamics and basic life history studies, both essential to management of the resource; but data are also needed on crab ecology, larval distribution and abundance, and the effects of pesticides and heavy metals on crab populations.

In 1970 the Department established a marine culture laboratory to investigate the mass culture feasibility for selected marine shellfish species, including the Dungeness crab. In the process of developing mass culture techniques for the crab we encountered high larval mortalities, particularly with early developmental stages. This caused speculation about the viability of newly hatched crab larvae. The nagging thought persisted that environmental pollutants had been transmitted from parent to offspring, at sublethal levels, but sufficient to affect larval viability.

To test this hypothesis we collected ovigerous crabs from the San Francisco region and the Eureka-Crescent City area to compare hatching success. The latter fishery had not experienced the long term decline in landings suffered in central California. Presumably differences in crab larval hatching success could account for the difference in the magnitude of the resources.

During the crab mass culture studies conducted in 1972-73, incidental data were gathered on size of the hatch and on larval release periods for

individual females. This report includes that data, but is comprised principally of data collected during the 1973-74 breeding season.

The objective of this study is to measure and compare crab hatching success from the two regions of the fishery and possibly relate these findings to the status of the resource.

MATERIAL AND METHODS

Ovigerous crabs, caught by commercial fishermen, were wrapped in seawater-saturated cheesecloth and packed in styrofoam containers for shipment to the laboratory. Refrigerant bags were placed in each container to maintain cool temperatures, alleviating possible heat stress to the crabs. Transit time to the laboratory did not exceed 24 hours.

Crabs were measured and examined upon arrival at the laboratory. Particular attention was focused on each egg mass, its size and coloration. Crabs were then placed in 75 liter (20 gal) aquaria, one per aquarium, and supplied with 15 μ- filtered, continuously flowing seawater.

Crabs were maintained on a market squid, *Loligo opalescens*, diet supplied fresh on alternate days. However, when larvae commenced to hatch, the market squid diet was discontinued.

Daily observations were made of egg shedding and egg mass coloration, coloration being indicative of embryo development within the egg capsules. Three color descriptions were used: yellow-orange, orange and brown. As developing embryos approached maturity, aquaria water inflows were shut off during non-observation periods (night hours) to insure larval retention. Aeration was substituted during these hours. A static, aerated system was maintained during the larval hatching period.

Upon hatching, the crab larvae (zoeae) were removed daily by siphoning. Zoeae were next concentrated in a sieve, transferred to a glass container, and brought to a final volume of 1, 2, or 3 liters (1.06, 2.12 or 3.18 qt), depending on larval density. Dense concentrations were brought to the 3 liter volume to facilitate counting. Two 25 ml (0.02 qt) aliquot samples were taken, and each was distributed into a separate dish. Live larvae were immobilized with 5% formalin, counted, and the counts from each dish averaged. Average counts were then multiplied by the appropriate factor for 1, 2, or 3 liter sample size to obtain the larval estimate. Dead larval counts were obtained similarly; however, these larvae accumulated on the aquaria floors, and did not require formalin treatment.

A coefficient of correlation was calculated to determine the relationship between adult crab size and the size of the larval hatch.

A Student's t-Test was used to determine if the mean hatching success of crabs from the two California regions was significantly different.

RESULTS

Ovigerous crabs were relatively easy to maintain in the laboratory although a few died. Cause of death may be attributable to shock stress while in transit, injuries in handling, or a combination of these.

Adult crabs displayed variable behavior in their feeding habits during the egg bearing period; feeding voraciously at times, and on other occasions exhibiting total indifference to introduced market squid.

Egg sponge coloration proceeds from a yellow-orange to orange to brown phase. The darker coloration is indicative of embryo chromatophore development, concomitant with maturation. We preferred to receive ovigerous specimens having orange to brownish egg sponges because maintenance time

in the laboratory prior to the zoeal hatch was abbreviated. Conversely, specimens having immature (yellow-orange) egg sponges required extended maintenance periods prior to hatching larvae. During this period the crabs constantly tended their egg masses, often tearing away substantial portions. Similar behavior probably occurs *in situ*, but it may be more pronounced in captivity. No attempt was made to measure the extent of this egg loss.

Duration of larval hatch per adult averaged about 8 days, ranging from 5 to 12. Hatching durations were similar for crabs originating from the San Francisco and Eureka-Crescent City regions.

The number of larvae hatched daily per adult followed a characteristic pattern; however, it did vary. Typically the first day's hatch was small (<4% of total), increased markedly on the second day, peaked on the third or fourth day, then tapered off to approximate the first day's hatch by the sixth day. Both the San Francisco and Eureka-Crescent City area crabs followed this hatching sequence (Figure 1).

Larval estimates were initially obtained from four crabs in January 1973. Origin data from three of these crabs were lost. The remaining crab, originating from the Eureka region, measured 169 mm (6.7 inches) shoulder width, hatched an estimated 574,100 larvae, of which 97.1% were alive. Hatching success of the three crabs with unknown origins also exceeded 90% (Table 1).

During the December 1973 - January 1974 period larval estimates were obtained from five crabs from the San Francisco region and six from the Crescent City area.

San Francisco region crabs had yellow-orange to orange colored egg sponges when first received. They were maintained for periods ranging

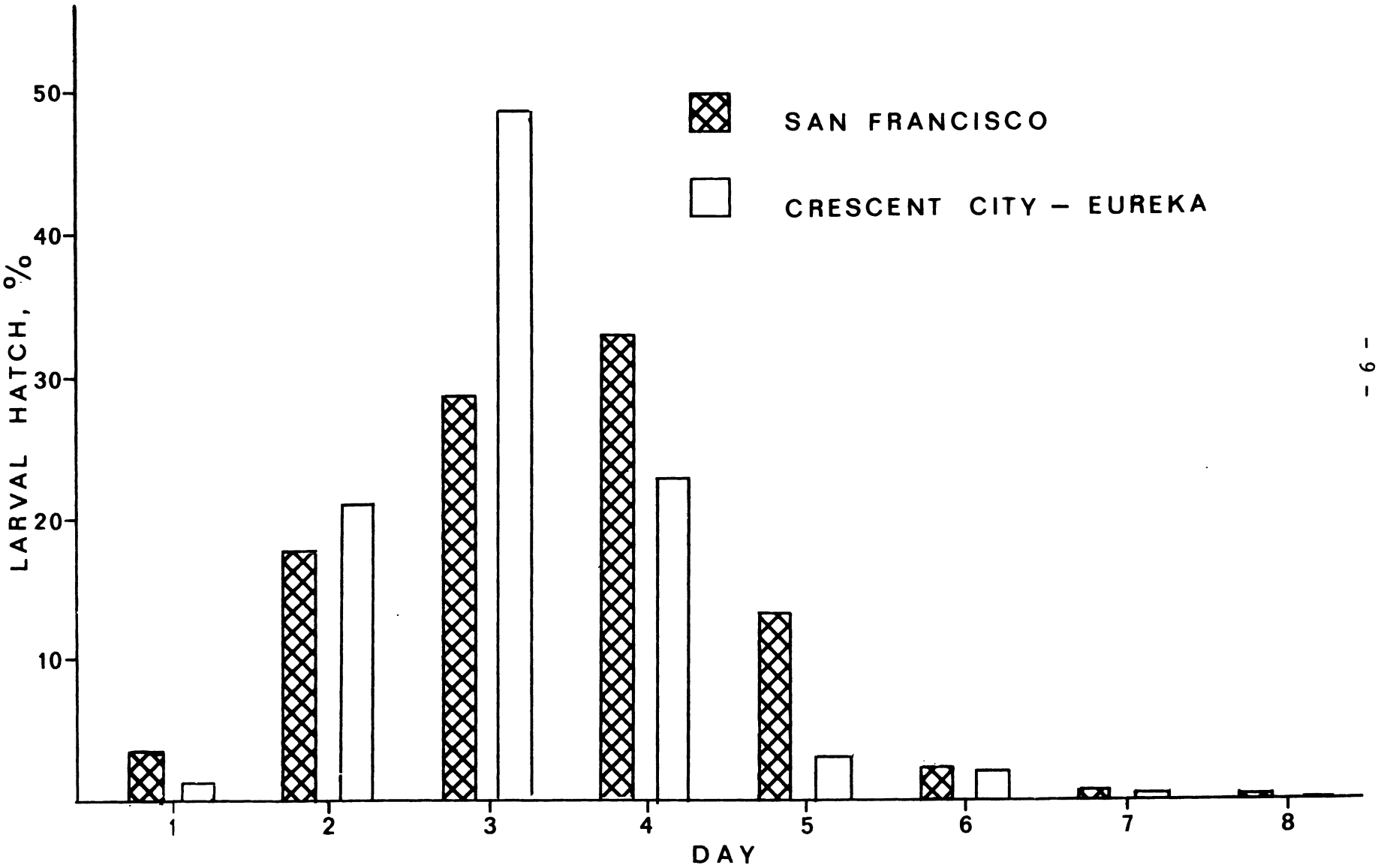

FIGURE 1. Larval release patterns for San Francisco and Eureka-Crescent City area ovigerous Dungeness crabs.

TABLE 1. Hatching Success of Dungeness Crab Larvae, *Cancer magister*, from Eureka and Unknown Origins, January 1973.

Origin	Female Shoulder Width, mm	Hatching Period	Larval Counts			% Survival
			Live	Dead	Total	
?	146	1/10/73 - 1/18/73	601,400	31,000	632,400	94.9
Eureka	169	1/11/73 - 1/19/73	557,700	16,400	574,100	97.1
?	136	1/13/73 - 1/20/73	820,200	21,800	842,000	97.3
?	161	1/19/73 - 1/26/73	303,100	24,800	327,900	91.9

from 14 to 36 days before the onset of larval release. Larval hatching success of three crabs exceeded 93%, another produced slightly better than 82% viable larvae, and the remaining crab had approximately 65% larval survival. This latter specimen, in addition to having poor larval survival, hatched a comparatively small number of larvae (Table 2). This crab did have a full, orange colored egg sponge when received. However, the egg retention time in the laboratory (36 days) to attain larval maturation and release exceeded that of other ovigerous crabs. Extensive egg shedding apparently occurred during the long egg tending period.

Crescent City area crabs had full brownish colored egg sponges when received, and with the exception of one individual, commenced to hatch larvae on the following day. Good larval hatching success was obtained, ranging from 92% to nearly 99%; averaging about 95% (Table 3).

Although Eureka-Crescent City area crabs exhibited slightly better hatching success than did crabs from the San Francisco region, the difference was not significant. Using an arc sine transformation of the percentages, and testing with Student's t-Test, $t = 2.12$ where $t_{.05,10} = 2.228$.

Total larval estimates per adult varied widely for similar sized crabs from both regions (Figure 2). A positive correlation would be expected between crab size and fecundity, and presumably the size of the larval hatch. Calculations disclosed a low to moderate positive correlation coefficient ($r = 0.44$). Egg shedding from handling of adults and, in some cases, extended periods in the laboratory prior to hatching larvae undoubtedly affected hatching success.

TABLE 2. Hatching Success of Dungeness Crab Larvae, *Cancer magister*, Originating from the San Francisco Region, December 1973 and January 1974.

Female Shoulder Width, mm	Hatching Period	Larval Counts			% Survival
		Live	Dead	Total	
158	1/16/74 - 1/23/74	1,122,400	67,600	1,190,000	94.9
169	1/4/74 - 1/15/74	1,088,900	53,200	1,142,100	95.1
162	1/14/74 - 1/19/74	349,000	61,300	410,300	82.4
151	12/6/73 - 12/10/73	314,700	21,000	335,700	93.3
145	1/15/74 - 1/23/74	61,200	33,600	94,800	64.6

TABLE 3. Hatching Success of Dungeness Crab Larvae, *Cancer magister*, Originating from the Crescent City Region, January and February 1974.

Female Shoulder Width, mm	Hatching Period	Larval Counts			% Survival
		Live	Dead	Total	
151	1/25/74 - 1/31/74	1,108,600	13,000	1,121,600	98.8
149	1/25/74 - 1/31/74	893,100	28,600	921,700	96.8
151	1/25/74 - 1/31/74	633,500	36,200	669,700	94.3
153	1/25/74 - 1/31/74	540,800	42,500	583,300	92.1
152	2/1/74 - 2/8/74	478,700	15,700	494,400	96.7
137	1/25/74 - 1/31/74	230,500	15,500	246,000	93.3

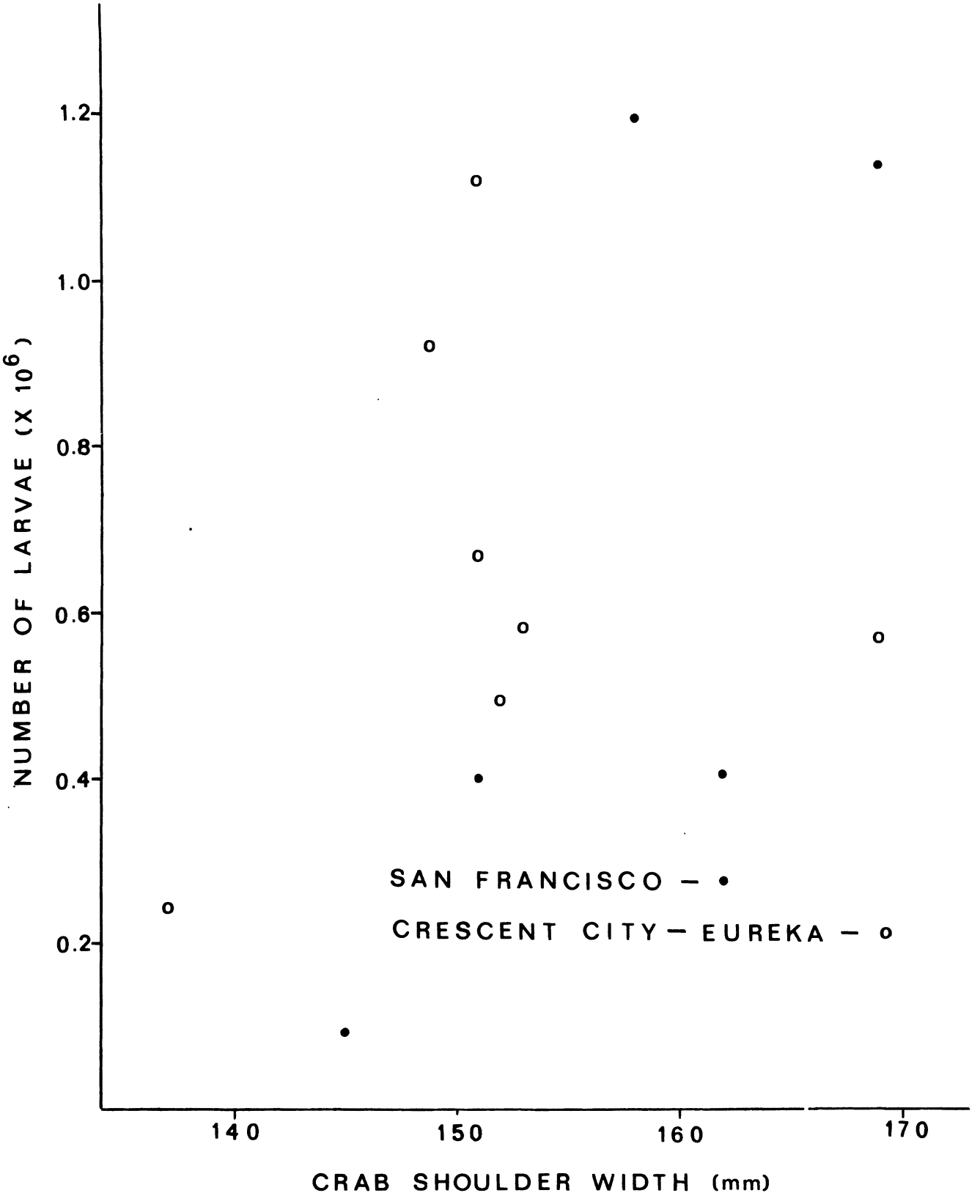

FIGURE 2. Dungeness crab larval hatch compared to adult crab size.

CONCLUSIONS

Because Dungeness crabs hatch-out viable larvae equally well from both coastal regions it would appear that other factors are involved in the overall fishery decline occurring off San Francisco. It is possible that subsequent larval stages become contaminated and succumb, via biological magnification through the food chain; or oceanographic conditions unfavorable to larval crabs could be responsible. These and other factors require investigation if we are to interpret the fishery decline and, if possible, bring the fishery back to former abundance levels.