mates of 4-6 mo gestation periods, which assume that copulation and conception do not occur until after weaning, seem reasonable if the blastocyst is implanted soon after conception, partially skipping or entirely skipping the delay period. Our field data and that from captive studies indicate that the gestation period in sea otters may be variable and depend on an external stimulus or the general well being of the female.

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THOMAS R. LOUGHLIN

Northwest and Alaska Fisheries Center
National Marine Fisheries Service, NOAA
7600 Sand Point Way NE
Seattle, WA 98115

JACK A. AMES

Marine Resources Branch
California Department of Fish and Game
2201 Garden Road
Monterey, CA 93940

JUDSON E. VANDEVERE

93 Via Ventura
Monterey, CA 93940

MASS MORTALITY OF FEMALE DUNGENESS CRAB, *CANCER MAGISTER*, ON THE SOUTHERN WASHINGTON COAST

Studies of growth and age of Dungeness crab, *Cancer magister*, populations from California to British Columbia have amply elucidated developmental rates for this species (Cleaver 1949; Waldron 1958; Butler 1961; Poole 1967), but no information is contained in such reports on mortality and its causes, apart from reference to known predators and cannibalism. Natural mortality for highly mobile crustaceans is difficult to investigate because animals simply do not expire in easily observed locations or are quickly removed by scavengers once dead. Consequently, there has been no documentation of extensive crustacean mortality by causes such as disease or pollution on the Pacific coast of the United States, and therefore loss from a population throughout its life cycle due to a generalized predator category (including fishing and cannibalism for *C. magister*, Botsford and Wickham 1978) remains the traditional mortality component of the literature on many crustaceans including Dungeness crabs.

On 18 April 1979 large numbers of dead Dungeness crabs on the beach at Grayland, Wash. (Figure 1), were reported to the Westport Field Office of the Washington Department of Fisheries (WDF). Inspection of the beach between Westport and the northern end of Willapa Bay confirmed that many Dungeness crabs had been washed ashore and, contrary to our initial supposition, were not exuvia which are often mistaken for dead crabs by the public. Preceding this instance, we had reports of dead crabs in the pots of commercial fishermen in Willapa Bay in February 1979, and these findings were verified by WDF personnel.

In response to the report of 18 April, five locales on the beach from Grays Harbor to Willapa Bay (Figure 1, Table 1) were quantitatively examined for dead crabs and the shoreline between these points was inspected from a car. All crabs along the five transects were counted and sexed, if possible, and 42 Dungeness crabs at transect 3 were measured to the nearest millimeter across the carapace inside the tenth anterolateral spines.

Results

Dead crabs found on the beach between Grays Harbor and Willapa Bay were confined to the line of previous high tide in a swath about 8-10 m wide.

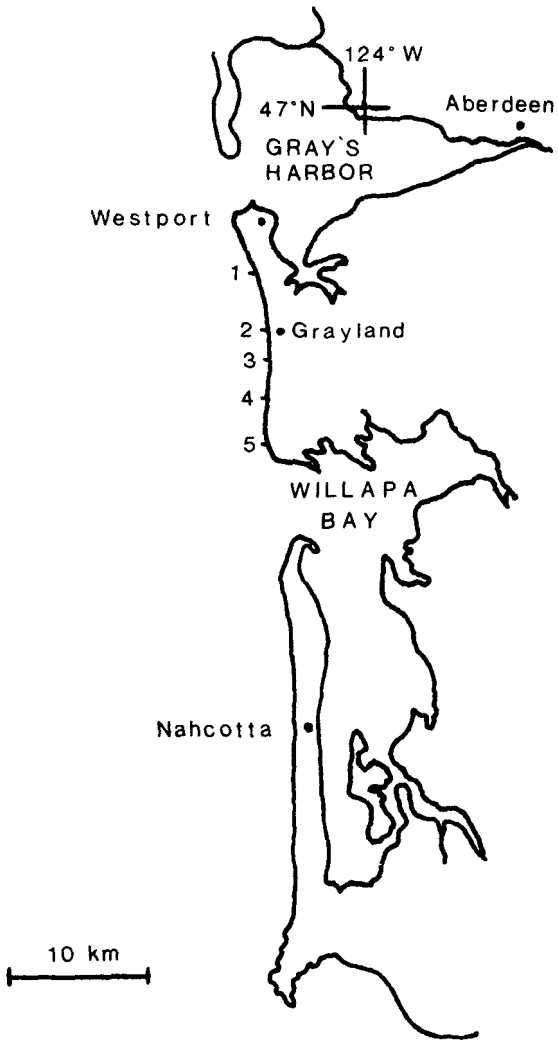

FIGURE 1.—Southern Washington coast and locations of numbered transects.

Nearly all animals examined contained musculature in the appendages and thoracic region and relatively few exuvia were found (Table 1). Because of decomposition and some bleaching of shells, animals were judged to have been on the beach 1-3 d and a relatively high percentage had been damaged by scavenging birds, thereby precluding identification of sex in those instances. Still, all Dungeness crabs sexed were females which, of the 42 measured, averaged 147 mm carapace width (range 110-162 mm).

TABLE 2.—Estimated number of dead Dungeness crabs, Grayland to North Cove, Wash., 18 April 1979.

Area	Crabs/m[1]	Distance between transects (m)	Estimated total no. dead crabs between transects
Grayland to county line (transects 2 to 3)	1.09	1,800	1,962
County line to Midway (transects 3 to 4)	1.15	2,700	3,105
Midway to North Cove (transects 4 to 5)	0.41	3,400	1,394
Total			6,461

[1]Average of two successive transects.

Substantial numbers of dead crabs were found with densities of up to 1.64 crabs/m of shoreline (in the 8-10 m band of upper high tide) computed at transect 3 (Table 1). Generally, the numbers of dead crabs observed between transects seemed consistent with the densities recorded along transects. Estimation of the total number of dead crabs on the beach between Grayland and North Cove (7.9 km) was 6,461 animals (Table 2).

Discussion

Mass mortality of *C. magister* has not, to our knowledge, been previously reported for any locale within this species range from central California to Alaska. At the time of the incidence we describe for southern Washington, there were no similar reports of mortality along Oregon beaches according to Dale Snow.[1] Furthermore, he had never verified an occurrence of extensive crab mortality in that state during 17 yr of fisheries research.

Does our report then, describe an isolated or rare phenomenon of this species or does an event such as mass mortality go undetected, observed but not interpreted for what it is? Along the Wash-

[1]Dale Snow, Oregon State Department of Fish and Wildlife, Newport, Oreg., pers. commun. April 1979.

TABLE 1.—Dead Dungeness crabs along measured beach transects in southern Washington (shown in Figure 1).

Area and transect no. on map	Dead crabs				Exuvia	Transect length (m)	Crabs/m	Cumulative distance (km)
	M	F	Unknown	Total				
Twin Harbors - 1	0	0	0	0	3	152	0.00	0.0
Grayland - 2	0	26	5	31	1	61	0.54	4.3
County Line - 3	0	81	21	101	2	61	1.64	6.1
Midway - 4	0	14	27	41	5	61	0.66	8.7
North Cove - 5	0	4	5	9	0	61	0.16	12.2

ington coast, *C. magister* females generally molt and breed in April through June (Cleaver 1949), and local residents are accustomed to the presence of numerous cast shells on the beach at that time. Since it occurred in the spring, the mortality, prior to our investigation, was probably mistaken for normal molting by many people including patrolmen of the local state parks. It is possible, therefore, that similar occurrences have gone unreported in the past due to such confusion; careful examination of the shells is required to detect tissues and distinguish dead animals from exuvia.

Since the original drafting of this report, two additional mortalities have come to our attention. On 29 November 1979, Walt Cooke[2] observed a large number of dead female Dungeness crabs on the beach from Ocean Park to Long Beach, Wash. (15.6 km). He estimated their number to be 955-1,910, of which only 2.5% were exuviae, and 93% of the remainder were females averaging 146 mm (n = 58) carapace width. On 30 January 1980, Darrell Demory[3] estimated a mortality of 68 crabs/km from the Umpqua River mouth north to Tahkenitch Creek, Oreg., (13.9 km) for an estimated total of 947, of which approximately 95% were females. Conditions of both these occurrences were similar to the April mortality; each consisted almost entirely of large female crabs confined to the high tide line, and occasionally in patches.

It is noteworthy that several instances of dead Dungeness crabs in commercial pots from Willapa Bay prompted investigations by one of the authors, David Armstrong, and personnel from WDF and the National Marine Fisheries Service in February and March 1979 (Tufts[4]). Moribund and dead crabs (male and female) were found in pots checked every 24 h, and some were recovered from shallow intertidal areas. This indicates that animals attracted to bait were healthy enough to enter pots, and then died within a short time thereafter. These observations were made following a severe cold spell during which the air temperature was below freezing for 2 wk, and parts of Willapa Bay had frozen over suggesting temperature stress associated with the mortalities.

Causes of the mortality of April 1979 are only speculative, since crabs could not be examined histologically. Immediately after verifying the report, we questioned WDF personnel to learn if nearshore groundfisheries might account for extensive crab mortality by trawling activity, and learned that no trawlers were known to be operating just prior to 18 April offshore from the transect locations. We surmise that death was due to disease, and the specificity shown for large, older females indicates a causative agent linked perhaps to a decline in vigor with old age. Female *C. magister* reach sexual maturity at about 100 mm carapace width in their second year and relatively few animals exceed 145-150 mm (Butler 1961; Poole 1967). The average carapace width of 147 mm for dead crabs at transect 3 shows a preponderance of older females were affected, perhaps because they were more susceptible to possible lethal stresses than younger animals.

Tissue samples dissected from moribund animals in Willapa Bay in March 1979 were studied for histopathological anomalies, and preliminary results indicate a systemic bacterial infection as a possible causative agent according to Sparks.[5] Lethal diseases among wild populations of *C. magister* are unknown but mortalities of laboratory-held animals have been attributed to such pathogens as fungus and ciliates (Armstrong et al. 1976; Armstrong and Sparks[6]). It seems likely that bacteria or various pathogenic protozoans may take a toll in wild populations, particularly in a segment of the population weakened or predisposed by contributing factors such as old age.

Demory (footnote 3) concluded that the mortality observed in January 1980 on the Oregon beaches may have been the result of stress on crabs trapped in pots that were "sanded in" during a period of adverse weather immediately preceding the observation, when fishermen could not pull these pots for several days. No diseases or parasites were found in specimens obtained from this mortality.

Although examples of mass mortality in crustacean populations are rare, the presence of numerous dead *C. magister* along a beach is reminiscent of the "Gray Crab Disease" affecting *Callinectes sapidus* on the east coast of the United States. Lethal infections attributed to the amoeba

[2]Walt Cook, Washington Department of Fisheries, P.O. Box 158, Ocean Park, WA 98640, pers. commun. 2 June 1980.

[3]Darrell Demory, Oregon State Department of Fish and Wildlife, Newport, Oreg., pers. commun. 5 February 1980.

[4]Dennis Tufts, Washington Department of Fisheries, P.O. Box 158, Ocean Park, WA 98640, pers. commun. 11 July 1980.

[5]Albert Sparks, National Marine Fisheries Service, NOAA, 2725 Montlake Blvd. E., Seattle, Wash., pers. commun. March 1979.

[6]D. Armstrong and A. Sparks, College of Fisheries, University of Washington, Seattle, WA 98195, unpubl. data on blood ciliates.

Paramoeba perniciosa have been found from Maryland to Georgia (Sprague et al. 1969; Mahood et al. 1970), and strong correlations were established between mass mortalities of blue crabs, high incidences of infection, and declines in commercial fishery landings (Mahood et al. 1970). Percentages of blue crabs infected with the disease range from 20 to 35% of captive animals in holding boxes (Sprague and Beckett 1966; Sawyer 1969) and from 7 to 17% in wild populations during the summer (Sawyer 1969; Sawyer et al. 1970; Newman and Ward 1973). As noted by Newman and Ward, epizootics attributed to this disease can be of short duration, killing significant numbers of animals and leaving no indication of the severity even to investigators purposefully seeking clues on occurrence and extent of infection.

The importance of these observations is, in part, as a reminder that significant loss from a population can result from factors other than predation. The nature of other mortality factors (be they disease, physical-chemical, or pollution) and the magnitude of their effects are largely unknown, particularly for highly mobile crustaceans. Still, the presence of over 6,400 dead adult female crabs along a segment of coastline in conjunction with the other two reports of mass mortality noted, indicates *C. magister* is susceptible to conditions and events that may occur on a seasonal basis. It is reasonable to assume that the crabs observed dead at the high watermark were only a fraction of the numbers affected offshore and, if so, then the magnitude of the mortality in this instance was certainly greater than that observed.

Whatever the cause of the mortality to *C. magister* in this case, and whether such an event is a common seasonal occurrence or a rare catastrophe, a partial loss of this reproductively significant age-group could have important consequences for the commercial fisheries.

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BRADLEY G. STEVENS
DAVID A. ARMSTRONG

College of Fisheries
University of Washington
Seattle, WA 98195