Compensatory Feeding Capacity of 2 Brachyuran Crabs, Tanner and Dungeness, After Starvation Periods Like Those Encountered in Pots

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Compensatory Feeding Capacity of 2 Brachyuran Crabs, Tanner and Dungeness, After Starvation Periods Like Those Encountered in Pots

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ABSTRACT: Food usage rates were measured in 2 brachyuran species, Tanner crab *Chionoecetes bairdi* and Dungeness crab *Cancer magister,* following starvation periods of 0, 30, 60, and 90 d. *F*-tests indicated that there was no compensatory feeding. Food usage rates within species were similar among the 4 test groups, regardless of the length of starvation. Food usage rates were approximately 0.4% body weight per day for Tanner crabs and 1.0% for Dungeness crabs. Neither species markedly increased its consumption rate to compensate for the nutritional deficits. Starvation periods as short as 30 d negatively affected survival of both species under laboratory conditions.

INTRODUCTION

Tanner *Chionoecetes bairdi* and Dungeness *Cancer magister* crabs are both important commercial species in Alaska. Every year 10–20% of the crab pots used to capture these crabs may be lost at sea while fishing (Breen 1990). In the southeastern Bering Sea alone it is estimated that 20,000 crab pots are lost annually (Alaska Department of Fish and Game staff testimony, March 1991, Alaska Board of Fisheries meeting). Lost pots may continue to capture crabs and fish until the escape mechanisms of biodegradable twine disintegrate (Kimker 1990). In Canada, mortality of Dungeness crabs in lost pots is estimated at 7% of landings (Breen 1990). Tanner crabs had mortality rates of 30–52% when held without food for 119 d in crab pots (Kimker 1994).

Alaska fisheries regulations (5AAC39.145 in ADF&G 1994) state that crab pots must have an escape mechanism; 100% cotton twine escape mechanisms use 30 thread for Tanner pots and 60 thread for Dungeness pots that experimentally disintegrate in 50 to 106 d. Thus, crabs trapped in derelict pots might not be able to forage for up to 100 d. This study measured the ability of Tanner and Dungeness crabs to offset nutritional deficits through post-starvation compensatory feeding, i.e., consumption rates that are higher than those occurring when individuals have continual access to food.

METHODS

Tanner and Dungeness crabs were captured by the Alaska Department of Fish and Game in pots near Homer, Alaska, and delivered to the Seward Marine Laboratory. All experiments lasted 230 d, which included the starvation period, 25 d of quantitative feeding, and survival assessment to day 230.

Tanner crabs were captured on 17 January 1992 in lower Cook Inlet. All crabs were put into wet lock boxes and transported dry to Seward via truck. To eliminate crabs injured during capture and transport, crabs were held until 19 March 1992 before beginning the experiments. The Dungeness crabs were captured in July 1992 in Kachemak Bay. They were held in the laboratory until 10 October 1992 when tank space was available to initiate the quantitative feeding experiments.

Bottom water temperatures in northern Gulf of Alaska bays where Tanner crabs are found annually range from 3° to 8° C (Smith et al. 1988;

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Stone et al. 1992). Dungeness crabs live at similar temperatures most of the year, but during summer some encounter temperatures of 10–15° C as they move into the intertidal region (NOAA 1970; Kondzela and Shirley 1993). Mean incoming seawater at the laboratory during the Tanner crab study was 4.4–5.5° C and was 5.8–8.1° C during the Dungeness crab study. Salinity of the seawater ranged from 31 to 33 ppt.

Starvation periods for both species were 0, 30, 60, and 90 d. During starvation periods each test group was held communally in a single 1,000-L tank. After specimens had been starved for the prescribed period, they were weighed to the nearest gram, held individually in 200-L tanks and fed daily for 25 d pre-weighed Pacific herring *Clupea pallasi* fillets. After crabs had ceased feeding on the daily meals, the blotted wet weight of remaining food was measured. Every day each individual's food use was recorded, and average daily consumption was calculated. The difference in the tissue weights at the beginning and end of the feeding session we called the food usage rate rather than the consumption rate. With both species it is difficult to measure actual consumption because during feeding some food floats away. Tanner crabs lose about 6% of prey weight into the water during feeding (Paul and Fuji 1989). The amount of food used was recorded as a percentage of the crab's initial body weight. Food usage, as a percent of body weight per day, by the different test groups was compared with a one-way analysis of variance.

For each species there were initially 10 individuals in each of the 4 test groups. The Tanner crabs were hard-shell males of legal size, >140 mm carapace width (CW). All of them were large-claw types with chela height-carapace width ratios >0.2 (see Stevens et al. 1993 for explanation of chela morphometry). At the start of Tanner crab observations, mean weights in kilograms (and standard deviations) in the test groups were 1.5 (0.2), 1.5 (0.2), 1.5 (0.1) and 1.4 (0.2) for those starved for 0, 30, 60, and 90 d, respectively. The Dungeness crabs were hard-shell sublegal (160-164 mm CW) and legal (165–198 mm CW) males. The mean initial weights in kilograms (and standard deviations) of Dungeness crabs were 0.8 (0.1), 0.8 (0.1), 0.8 (0.1) and 0.8 (0.1) in the test groups starved for 0, 30, 60, and 90 d, respectively.

After the 25-d quantitative food intake experiment, each group was put together into single 1,000-L tanks and fed every other day, to excess, in order to examine possible latent mortality due to starvation stress. This feeding regime ensured that food was always present in the tank. Observations were continued until day 230.

RESULTS

Tanner Crab

Test groups consumed similar mean tissue weights after being starved for either 0, 30, 60, or 90 d (Table 1). There were no significant increases ($P = 0.42$) in the food usage rates of the 3 starved groups over that of the control, indicating consumption was not elevated to compensate for starvation. Mean food usage rate for the group starved 60 d was the same as for the control group: 0.43% body weight per day. In the groups starved for 30 d and 90 d, food usage rates (0.31% and 0.39%, respectively) were less than that of the control group.

One individual starved for 90 d died before the end of the quantitative feeding experiment; all others survived to the end of the 25-d feeding trials (Table 1). However, following the 25-d quantitative feeding experiments long-term observations revealed latent mortality. Starved group mortalities were from 40% to 100% compared to no mortalities for individuals with continual access to food (Table 2).

Dungeness Crab

Food intake by Dungeness crabs was not related to the length of time they were starved. Mean food

Table 1. Food usage (as percent body weight per day) of Tanner crabs following starvation for periods of 0 to 90 d and mean water temperatures for each group.

	Food Usage by Starvation Group (d)			
	0	30	60	90
Crab No:				
1	0.40	0.34	0.52	0.42
2	0.56	0.39	0.43	0.44
3	0.38	0.33	0.39	0.20
4	0.60	0.42	0.42	0.40
5	0.41	0.22	0.41	0.65
6	0.32	0.38	0.36	0.25
7	0.40	0.32	0.55	0.40
8	0.33	0.36	0.42	0.42
9	0.36	0.32	0.50	0.36
10	0.56	0.05	0.34	dead
Mean	0.43	0.31	0.43	0.39
SD	0.10	0.10	0.06	0.12
One-way ANOVA: $F = 3.04$, $P = 0.42$ (not significant)				
Mean temp (°C)	4.4	4.6	5.1	5.5
SD	0.2	0.2	0.2	0.3

Table 2. Mortality rates (%) in 4 groups of Tanner crabs and Dungeness crabs held for 230 d beginning with a starvation period of 0 to 90 d followed by access to unlimited food for the reminder of the experiment.

	Mortality (%) by Starvation Group (d)				Number per	
Species	0	30	60	90	Group	Mean °C
Tanner	0	60	40	100	10	5.9
Dungeness	20	80	80	40	10	5.5

usage rates for test groups were 0.91% to 1.2% body weight per day (Table 3) and were not significantly different ($P = 0.18$; Table 3) among the 4 test groups.

Three individuals in the group starved for 30 d died during their quantative feeding trial, but all others survived to the end of the trial (Table 3). There was no apparent reason for these deaths. Starved groups had mortality rates of 40–80%; the control group which had continual access to food had 20% mortality (Table 2).

Table 3. Food usage (as percent body weight per day) of Dungeness crabs following starvation for periods of 0 to 90 d and mean water temperatures for each group.

	Food Usage by Starvation Group (d)			
	0	30	60	90
Crab No:				
1	1.16	0.69	1.38	1.11
2	1.35	1.08	0.96	1.30
3	1.18	0.52	1.04	1.22
4	1.23	1.04	1.07	1.38
5	1.26	1.02	1.42	0.99
6	1.52	1.44	1.27	1.13
7	0.12	0.58	1.10	1.12
8	1.03	dead	1.00	1.33
9	1.42	dead	1.08	1.19
10	1.06	dead	1.00	1.18
Mean	1.13	0.91	1.13	1.20
SD	0.39	0.33	0.16	0.12
One-way ANOVA: $F = 1.68$, $P = 0.18$ (not significant)				
Mean Temp (°C)	7.8	8.1	6.9	5.8
SD	0.7	0.4	0.8	1.1

DISCUSSION

The metabolic rate of crabs increases with ambient temperature (Paul and Fuji 1989), and food intake rates can markedly change in response to thermally altered metabolic needs (Kondzela and Shirley 1993). Dungeness crabs at 15 °C eat about 5 times as much food as cohorts held at 5 °C (Kondzela and Shirley 1993). In these experiments crabs were held at nonstressful temperatures ranging from 5.8° to 8.1 °C. Within this intentionally limited thermal range, mean food usage rates were similar during the warmest and coldest quantitative feeding tests, indicating that temperature in this study had minimal effect on feeding.

Our laboratory observation of high long-term mortality of unfed Tanner crabs is consistent with mortality rates of individuals held in crab pots (Kimker 1994). In that experiment Tanner crabs were held in crab pots for 119 d and mortality rates were 30% to 52%.

The 20% mortality among the continually fed Dungeness crabs and the higher rates in the starved groups suggest that this group of animals was very susceptible to the stresses of capture, handling, and captivity. Future studies with them might be better carried out in the field rather than in the laboratory.

Neither Tanner nor Dungeness crabs demonstrated capacity for compensatory feeding, but the importance of this finding cannot be judged without further study. In this simplistic experiment specimens were provided with food after starvation, but in nature they would have to forage. The effects of starvation on crabs detained in lost or untended pots need further study; e.g., would their presumably weakened condition affect vigor, foraging capacity, growth, reproduction, cannibalism, and survival? Monitoring the fate of experimental individuals carrying ultrasonic tags (Stone et al. 1992) might be one way to undertake *in situ* experiments that track the fate of crabs after escaping from varying periods of entrapment in pots.

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