Weight change of pink shrimp, *Pandalus jordani*, after commercial harvest and handling

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The northeast Pacific trawl fishery for pink shrimp, *Pandalus jordani*, is unusual in that it is primarily managed by an aggregate size limit. Vessels are required to land catches with a minimum average size of 353 shrimp per kg (160 shrimp per lb). The regulation is intended to limit fishing mortality on age-one shrimp, and also to maintain the economic value of the catch (PFMC, 1981). The decision to retain shrimp from a particular tow is made by fishermen at sea; however, the regulation is enforced when the shrimp are landed in port, up to five days later. In general, a knowledge of how commercial fishing practices can influence the average weight of target species is important for effective management by an aggregate size limit (Kirkley and DuPaul, 1989). Accordingly, the objective of this study was to quantify changes in the average weight of pink shrimp from initial retention to shoreside delivery, using normal commercial handling and icing procedures.

Methods

To assess the weight change of shrimp from commercial handling practices, we compared the weight of shrimp samples taken directly from the trawl nets of commercial vessels at sea to the weight of the same samples during the subsequent shoreside delivery. Four to eight replicate samples of approximately 500g were collected from each tow and weighed to the nearest 0.1g with a magnetically dampened triple beam balance. The accuracy of the scale was checked by using a known weight prior to each trip and again prior to weighing the samples at the dock. The scale used had also been previously tested for accuracy at sea with blind weighings and had been shown to produce measurements with a coefficient of variation of less than 0.5% under a variety of sea conditions[1]. Each sample was placed in a 5-mm mesh bag, labeled and passed to a crew member. Shrimp were taken directly from the vessel's hopper and were not washed prior to weighing and bagging. The crew was instructed to distribute the sample bags throughout the other shrimp from the same tow. After placement of the samples, the crew shoveled and raked flake ice into the layers of shrimp, according to that vessel's normal procedures.

At the completion of the fishing trip, the bags were retrieved during unloading and inspected for punctures. Punctured bags were discarded. Each intact sample was opened, placed in a tub with a 7-mm mesh bottom to drain for one minute, and weighed again with the same scale. An estimate of the percentage of ice in the gross load was obtained from processing plant records.

Weight change was expressed as a percentage of the original sample weight. The average percent weight change for all samples combined, for each trip and for each day of fishing, was compared to a hypothetical weight loss of zero percent by using a one sample t-test. To facilitate comparisons of weight change between trips or between individual days of fishing, 95% confidence intervals were constructed for each estimate of average weight loss. Scatter plots of percent weight change for individual samples versus elapsed time were constructed for each trip and for all trips combined. Each graph was tested for a significant slope with simple linear regression.

Results and discussion

Seven sampling trips were completed aboard commercial shrimp vessels between April and August 1988, lasting from 1 to 5 days. We recovered 70% of the mesh bags intact, resulting in weight change estimates for 713 samples from 132 tows. Elapsed time from catch to unloading ranged from 4 to 121 hours.

Percent weight change for the combined samples showed an approximately normal distribution centered on a mean weight loss of 2.2%, with a 99% confidence inter-

[1] M. Saelens and R. W. Hannah. 1988. Oregon. Dep. of Fish and Wildlife, Newport, OR 97365. Unpub. data.

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Table 1

Mean percent weight change, standard error of the mean and number of days on ice, between capture and unloading, for 500-g samples of pink shrimp, *Pandalus jordani* (number of samples is in parentheses). Asterisks denote results significantly different from zero percent weight change.

	Days on ice					
Trip	1	2	3	4	5	All days combined
1	−1.2 ± 0.9 (15)					−1.2 ± 0.009 (15)
2	0.4 ± 0.4 (11)	−0.3 ± 0.5 (14)	−1.8 ± 0.8 (9)	−4.1 ± 1.3 (3)		−0.7 + 0.4 (37)
3	−5.9[a] ± 0.8*** (14)	−0.4 ± 0.5 (25)	−1.8 ± 0.5** (17)	1.3 ± 0.6* (35)	−3.1 ± 0.9** (33)	−1.5 ± 0.4*** (124)
4	−2.1 ± 0.3*** (20)	−1.3 ± 0.3*** (28)	0.7 ± 0.5 (42)	0.9 ± 0.4* (30)		−0.2 + 0.2 (120)
5	−2.6 ± 0.3*** (23)	−5.4 ± 0.9*** (23)	−2.5 ± 0.5*** (24)	−2.2 ± 0.8* (19)	−4.6 ± 0.7*** (12)	−3.4 ± 0.3*** (101)
6	−4.7 ± 0.3*** (34)	−4.1 ± 0.4*** (43)	−5.2 ± 0.5*** (46)	−4.4 ± 0.5*** (32)		−4.6 ± 0.2*** (155)
7	−2.7 ± 0.2*** (24)	−2.0 ± 0.3*** (36)	−1.3 ± 0.4** (35)	−2.5 ± 0.3*** (45)	−0.4 ± 0.5 (21)	−1.9 ± 0.2*** (161)
All trips						−2.2 + 0.1*** (713)

[a] No ice used on this day of fishing. *$P<0.05$; **$P<0.01$; ***$P<0.001$.

Table 2

Summary of sampling trips, including trip length (d), total net landed catch (kg) and the estimated percentage of ice in the gross load (from processing plant records).

Trip	Trip length (d)	Total catch (kg)	Estimated percentage ice
1	1	600	35
2	4	7,900	16
3	5	15,000	17
4	4	11,900	23
5	5	5,200	32
6	4	25,200	7
7	5	14,000	11

val of 1.9% to 2.5% (Table 1). Four of the seven trips showed a statistically significant average weight loss ($P<0.05$), whereas three did not. None of the trips showed a gain in average weight of the shrimp samples, despite ice deductions as high as 35% of the gross load (Table 2).

The average weight change for samples from individual days and trips showed a large degree of variability. Several of the regressions of percent weight change versus elapsed time were statistically significant ($P<0.05$); however, the sign of the slope coefficient was inconsistent (Table 3). No consistent patterns were observed between average weight loss and trip length, total catch, or the percentage of ice in the load (Tables 1 and 2). The average weight loss observed in samples which had been on ice for only a short period of time (Table 1 and Figure 1), in combination with the significant positive slope of several of the regressions, suggests that commercially handled, iced pink shrimp generally lose some weight very shortly after capture, and, in many instances, slowly gain weight for some time afterwards. However, the one regression with a positive intercept and significant negative slope (Table 3, trip 2), in combination with the variability of average weight change (Table 1), demonstrate that weight change of shrimp under actual commercial handling and icing conditions is quite variable. The lack of a truly consistent pattern of weight change versus elapsed time suggests that Figure 1 may portray shrimp weight change under actual commercial fishing conditions as well as anything else presented.

Table 3
Summary of linear regression analysis of percent weight change on elapsed time for each trip and all trips combined. Model is Percent Weight Change = $a + b$ (Elapsed Time). NS = not significant.

Trip	Intercept	Coefficient	P>F
1	-0.207	0.013	0.0002
2	0.023	-0.001	0.0001
3	—	—	NS
4	-0.024	0.00041	0.0001
5	—	—	NS
6	—	—	NS
7	-0.027	0.00014	0.0238
All trips	-0.029	0.00013	0.00027

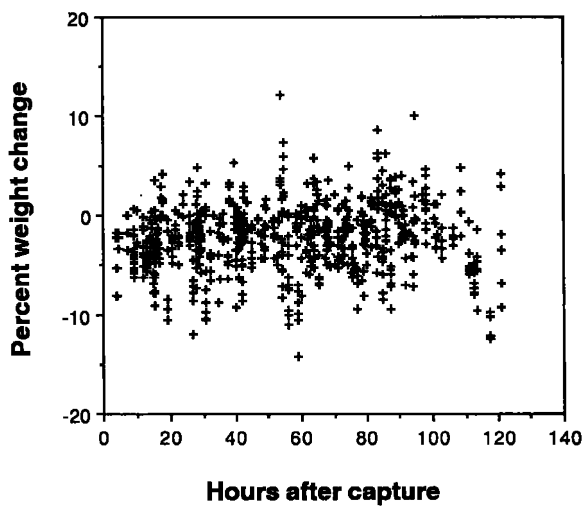

Figure 1
Percent weight change versus elapsed time from capture to unloading for samples of trawl caught pink shrimp (N = 713)

Interestingly, there were daily average weight change values which exhibited a significant positive change (Table 1), probably owing to absorption of meltwater from the ice. Samples from two trips showed large deviations from the average weight change which were readily explainable. On trip 3, the vessel ran out of ice on the final day of fishing, and, on trip 6, some spoilage was found throughout the load suggesting inadequate icing. In both cases the samples showed high weight loss values, 5.9% and 4.6% respectively.

These data suggest that there are small but fairly consistent losses in average weight of pink shrimp between commercial capture and unloading, at least when the shrimp are adequately iced. The results of this study appear to conflict with the findings of Bullard and Collins (1978), that iced *Pandalus borealis* gained 11% in weight in the first 1.5 days and maintained this gain for 8.5 days. However, the different methods used readily explain the different findings of the two studies. Bullard and Collins (1978) worked with shrimp which had been held at −1.7°C for two hours and then rinsed and drained for 30 minutes to produce stable weights prior to icing. The shrimp employed in this study were very fresh, sometimes jumping off the scales. If the average weight loss observed in this study occurs very rapidly, perhaps owing to loss of fluids just after the shrimp have died, or from the initial crush of the catch in the hold, such a loss could not have been detected in the Bullard and Collins (1978) experiment. It is not clear what percentage of ice was used by Bullard and Collins (1978), but they refer to it as "an excess of ice." Given the weight gain observed in some of the samples in this study, and the modest percentages of ice (Table 2), the results of the two studies are not inconsistent. Perhaps, however, the differences do suggest the importance of studying the weight change of shrimp under both laboratory and actual commercial fishing conditions.

An average weight loss of 2.2% from capture to unloading is sufficiently small as to be insignificant from a management standpoint. The minimum aggregate size limit of 353 shrimp per kg (160 shrimp per lb), which is intended to provide some protection from harvest for age-one shrimp, is based on average size-at-age data. Interannual and geographic variability in shrimp growth easily exceeds 2.2% (Hannah and Jones, 1991). The findings of this study are significant however, principally in that they demonstrate that the change in weight of pink shrimp that should be expected, when using normal icing procedures, is fairly small. Accordingly, fishermen can readily comply with the minimum size regulation.

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Literature cited

Bullard, F. A., and J. Collins.
1978. Physical and chemical changes of pink shrimp *Pandalus borealis*, held in carbon dioxide modified refrigerated sea water compared with pink shrimp held in ice. Fish. Bull. 76:73–78.

Hannah, R. W., and S. A. Jones.
1991. Fishery induced changes in the population structure of pink shrimp (*Pandalus jordani*). Fish. Bull. 89:41–51.

Kirkley, J. E., and W. D. DuPaul.
1989. Commercial practices and fishery regulations: the U.S. northwest Atlantic sea scallop, *Palcopten magellanicus* (Gmelin, 1791), fishery. J. Shellfish Res. 8(1):139–149.

PFMC (Pacific Fishery Management Council).
1981. Discussion draft fishery management plan for the pink shrimp fishery off Washington, Oregon, and California. PFMC, 169 p.