Correlation of winter temperature and landings of pink shrimp *Penaeus duorarum* in North Carolina

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William F. Hettler
Beaufort Laboratory, Southeast Fisheries Science Center
National Marine Fisheries Service, NOAA, Beaufort, North Carolina 28516-9722

In habitats where low water temperature is not a limiting factor, pink shrimp *Penaeus duorarum* production has been related to rainfall and surface-water inflow (Browder 1985, Sheridan 1991). In contrast, North Carolina landings of pink shrimp were correlated with water temperature during the previous winter, but not to rainfall (Hettler and Chester 1982). In that study, the average water temperature of the two coldest consecutive weeks of each year recorded at a single temperature station located at the Beaufort Laboratory was a predictor of spring landings (through July) for the entire North Carolina fishery. Fifteen years of temperature records and landings were used to determine this relationship. Since the last year reported (1981), 10 additional years of temperature and landings data have become available. This note presents these new data and uses the resulting 25-year time-series to report that average minimum winter water temperature remains a reliable basis for forecasting landings of this species.

The temperature/landings relationship previously published (Hettler and Chester 1982) was recalculated after adding the 1982–91 temperature and landings data (Table 1, Fig. 1). No evidence of curvilinearity in the relationship could be found by fitting higher-order polynomial models. A time-series model was not appropriate because pink shrimp are 'annuals' and their annual population levels generally show low autocorrelation as suggested by the 1962–91 North Carolina pink shrimp heads-off landings data (Fig. 1). Thus the simple linear model was retained. The new regression to determine spring pink shrimp landings in North Carolina was

$$\text{Landings (kg)} = 83747(T) - 245208,$$

where T was the average temperature of the two coldest consecutive weeks (°C). The relationship was significant ($P<0{:}001$, r^2 0.803). The more general relationships of average winter water temperature (Dec–Mar) or average midwinter water temperature (Jan–Feb) did not correlate with landings over the 25-year time-series.

Table 1

Actual and predicted landings (heads-off) of pink shrimp *Penaeus duorarum* in the North Carolina spring fishery, February–July, based on average water temperature of the two coldest consecutive weeks of the preceding winter.

Year	Temp. °C	Landings (kg)		Percent over (+) or under (−)
		Actual	Predicted	
1982	5.0	197,630	173,527	+13.9
1983	8.8	451,163	491,765	−8.3
1984	5.9	184,380	248,899	−25.9
1985	5.4	126,797	207,025	−38.7
1986	6.9	307,514	332,646	−7.6
1987	8.3	551,521	449,892	+22.6
1988	6.1	433,125	265,648	+63.0
1989	8.1	639,166	433,142	+47.5
1990	3.7	66,853	64,656	+3.4
1991	10.0	592,381	592,262	<+0.1

Predicted landings of pink shrimp were calculated and averaged within 25% of the actual landings for the recent 10-year period. Landings in 1991 were within >0.1% of the prediction. Possible causes of the relatively large deviations in some years' landings from the predicted are discussed in Hettler and Chester (1982) and include errors in the process of estimating landings, year-to-year changes in fishing effort, and, in addition, possible local thermal anomalies.

These new data continue to support the hypothesis that reduced pink shrimp landings in North Carolina are probably a result of cold kill of overwintering shrimp caused by cold water temperatures. In the coldest years (1963, 1977, 1978, and 1990) when spring landings were less than 100,000 kg, lethal cold water probably penetrated all but the most highly protected overwintering estuarine habitat. North Carolina is the northern limit in the range of pink shrimp, thus this species is more likely to encounter low temperature stress in this location than in more southerly locations. The linearity of the model is perhaps a consequence of these shrimp's inherent vulnerability to cold water temperatures interact-

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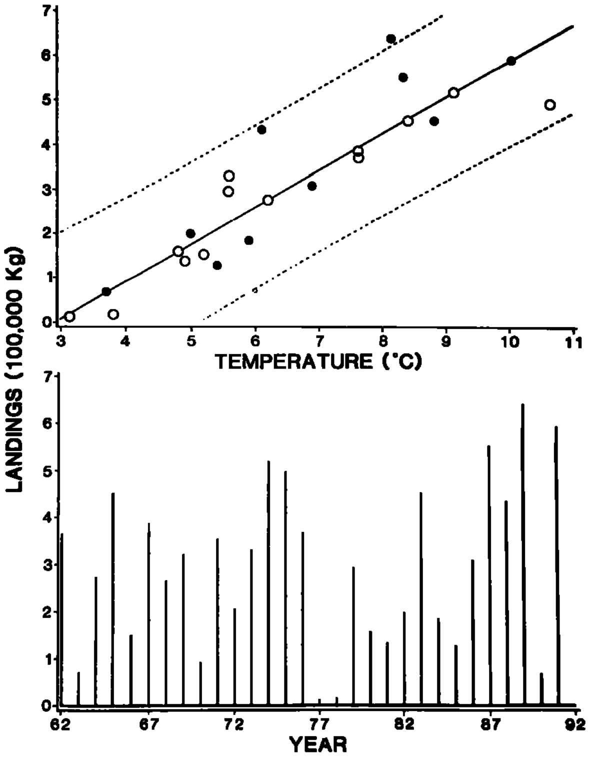

Figure 1
(Upper) Regression and 95% confidence limits for 25 years of temperatures and landings (heads-off) of pink shrimp *Penaeus duorarum*. Open circles represent years before 1982 reported by Hettler and Chester (1982); closed circles represent the years 1982–91. (Bottom) Spring landings (heads-off) of pink shrimp in North Carolina since 1962.

ing with the geographical/spatial distribution and availability of habitats that respond differently to dropping temperatures. The safest habitats would include favorable sediments for deep burrowing, deep water, and physiologically isosmotic salinity.

Acknowledgment

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Citations

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