# SALINITY PREFERENCES OF HUDSON RIVER ADULT MALE BLUE CRABS *Callinectes sapidus*

A Final Report of the Tibor T. Polgar Fellowship Program

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## ABSTRACT

Adult male blue crabs were individually tested for salinity preference by allowing them to move freely among three chambers, each containing water of a different salinity. Crab movement among chambers and the length of time spent in each chamber were digitally recorded and analyzed. Three exposure conditions were tested: crabs adapted to low salinity (5 ppt), low temperature (18°) (n=14); low salinity (5 ppt), high temperature (24°C) (n=24), and high salinity (20 ppt), high temperature (24°C) (n=10).

Under control conditions (all chambers contained 5 ppt water), crabs (n=10) on average spent an equal amount of time in each chamber. When these same crabs were allowed to choose between salinities (low salinity=0 ppt, adaptation salinity=5 ppt, and high salinity=10 or 20 ppt) in paired trials, the crabs spent a significantly greater percentage of time in their adaptation salinity (5 ppt) or higher (10 or 20 ppt). However, crabs showed no significant difference in the number of entries into either the low salinity or high salinity choices.

Crabs exposed to the other two acclimation conditions (low salinity, low temperature and high salinity, high temperature) showed poor survivorship, resulting in sample sizes that were too small for statistical analysis. However, of crabs exposed to low salinity and low temperature (n=14), 4 of 7 demonstrated a preference for the adaptation salinity or one that was higher. The remaining three did not demonstrate emersion during the trial, and seven died before they could be tested (50% mortality rate). Adult male blue crabs (n=10) placed in high salinity and high temperature showed a 90% mortality rate.

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## INTRODUCTION

The blue crab, *Callinectes sapidus*, is a euryhaline, estuarine-dependent species inhabiting waters along the western Atlantic from Nova Scotia to Uruguay (Williams 1974, Gunter 1938). It is most commonly appreciated by humans for its commercial and recreational value (Messick and Sindermann 1992). The blue crab also plays a vital role in shaping the structure of its ecological community, serving as predator (Hill et al. 1989, Virnstein 1977) and prey for species such as striped bass, clams, and oysters (Wilson and Able 1992).

The blue crab has played a significant part in the economy of the mid-Atlantic region, and more specifically, in the Chesapeake Bay region between Maryland and Virginia (Hill et al. 1989). The Chesapeake Bay area supported 35% to 50% of the total U.S. commercial blue crab harvest from 1977-1997 (Normandeau 2004, Miller 2001, Hill et al. 1989). Much of the research done on the biology of the blue crab stems from the Chesapeake Bay region, the center of distribution for this species (Miller 2001, Abbe and Stagg 1996, Baird and Ulanowicz 1989, Cargo 1954, Hill et al 1989, Hines et al. 1987, 1990, Hurt et al. 1979, Lipcius and Van Engel 1990, Schaffner and Diaz 1988, Sharov et al. 2003, Van Heukelem 1991, Volstad et al. 2000).

Although New York has historically had lower blue crab harvests than the Chesapeake Bay area, its crabbing industry has grown steadily since the 1970's (Briggs 1998, Stehlik et al. 1998, Normandeau 2004). The most productive pot fisheries in New York state are located in Great South Bay and in other bays along the south shore of Long Island. New York harbor also supports a significant late fall and winter commercial dredge fishery (Stehlik et al. 1998). The Hudson River is now an active site

for summer pot fishing (Kenney and Cosman 2001). Despite the increasing fishery activity in New York, these blue crabs at the northern end of their biogeographical range remain largely unstudied (Normandeau 2004).

Much of what is known about the life cycle of blue crabs in the Chesapeake Bay is expected to apply to blue crabs in the Hudson River estuary (Van Engel 1958). For instance, blue crabs mate during summer and fall, and mature females release their eggs in the higher salinity waters of the lower estuary (Hill et al. 1989). Hatching of eggs requires salinities of 23-33 parts per thousand (ppt) and temperatures between 19-29 °C. Larval (zoeal) and megalopal stages also occur in the higher salinity waters of the continental shelf. Larvae molt seven or eight times during the 31-49 days before reaching the megalopal stage or second larval stage. The megalopal stage lasts for 6-20 days, and is followed by the first crab stage (juvenile stage). At this stage, the juveniles are morphologically similar to adult crabs with the exception of size. Juvenile crabs continue to molt, increasing in size by approximately 25%-40% with each successive molt (Hill et al 1989). Molt increase in size appears to be influenced to a large extent by environmental conditions such as salinity and temperature (Fisher 1999). Juveniles undergo an average of nine to ten molts during the first year. Molting and growth stop during the winter months, and resume in the late spring or early summer when water temperatures increase. Crabs generally reach maturity during the second year after hatching. Females and young juvenile blue crabs are found primarily in higher salinity waters, but males are prevalent in brackish and fresh water (Hill et al. 1989).

Although crabs inhabiting the Chesapeake Bay and crabs inhabiting the Hudson River share many similarities, one difference between the two populations may be the

utilization of lower salinity areas of the estuary during the winter months (Normandeau 2004). During the winter in the Chesapeake Bay area, both male and female blue crabs are commonly captured in lower salinity areas of the estuary (0-10 ppt). These crabs burrow into the mud during the winter and are captured by dredging. In contrast, in the Hudson River, a recent winter dredging study found few crabs overwintering north of river mile (RM) zero where salinities ranged from 0-15 ppt during the winter of 2003 (Normandeau 2004). Wilson and Able (1992) also observed reduced numbers of blue crabs upriver in the Hudson in the early spring compared to downriver. These results suggest that Hudson River blue crabs may migrate down river during the late fall and return to lower salinity waters upriver in the spring and summer. Blue crabs at the northern end of their biogeographical range may differ in overwintering strategy from the center of distribution (Wilson and Able 1992, Normandeau 2004, Miller 2001).

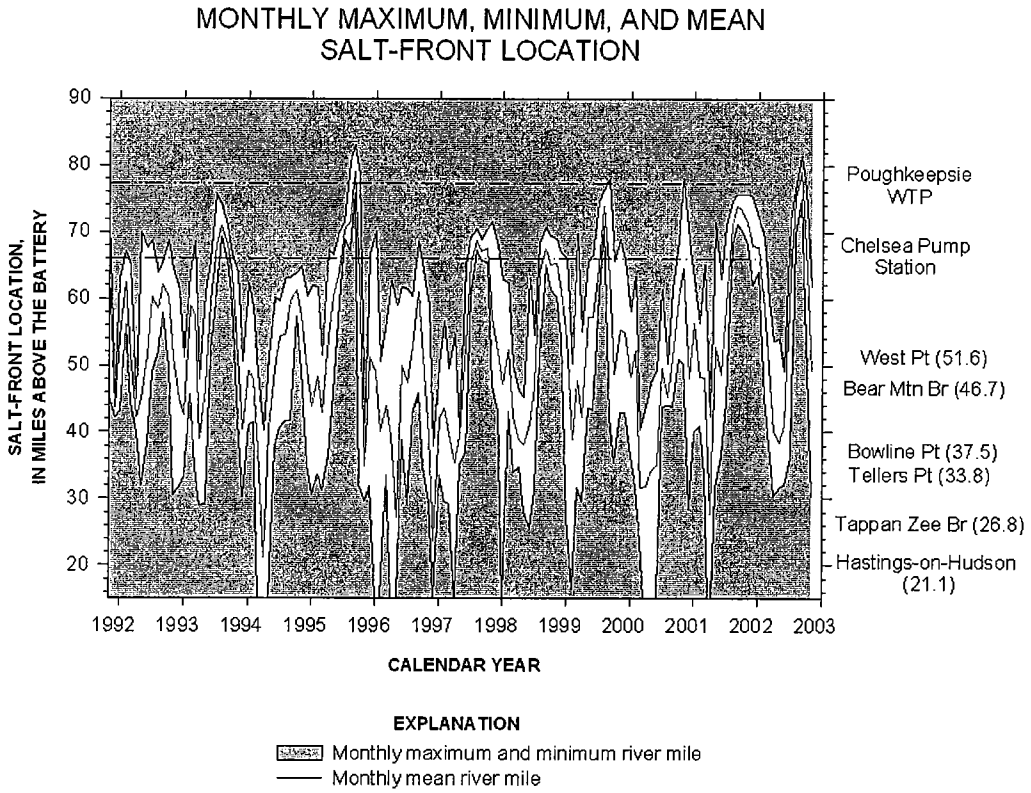
The ability of the blue crab to enter fresh water was not widely documented in the scientific literature until the first half of the twentieth century. Hay (1905) noted several instances of the blue crab in inland coastal waters in the Chesapeake area. Churchill (1917) also cites several examples of the blue crab in fresh water. Gunter (1938) recorded the capture of a male blue crab 160 miles upriver from the Gulf of Mexico. He further noted that commercial fishermen commonly caught blue crabs at that location during the summer. From this evidence, Gunter (1938) concluded that blue crabs probably could be found in freshwater tributaries throughout their entire range. Rathbun (1896) documented the presence of the blue crab in fresh water in the Hudson River at West Point, as well as in fresh water in Jamaica at the mouth of the Rio Cobre.

Salinity and growth show an inverse relationship in this species such that as salinity decreases, growth per molt increases (Stehlik et al. 1998, Wilson and Able 1992, Fisher 1999, Van Engel 1958, Tagatz 1968). Temperature, food availability and season also impact growth in crustaceans (Aiken and Waddy 1986, Hines et al. 1987, Gunderson et al. 1990, Fisher 1999). In blue crabs, as is the case with many other decapod crustaceans, larger males are generally more successful in access to females, food acquisition, and in sperm competition (Jivoff 1997, Thornhill and Alcock 1983, Andersson 1994). Jivoff (1997) found that large blue crab males had both greater access to fecund females and had larger ejaculate volume, resulting in greater mating success.

Salinity in the Hudson River varies according to geographic location, as well as both seasonally and from year to year (Figure 1) (http://ny.water.usgs.gov/projects/dialer_plots/rmmonth_periodofrecord.html). Fluctuations in salinity depend upon factors such as annual precipitation in the form of rainfall or snowmelt, drought, tides, and severe weather patterns such as hurricanes (Kenney et al. 2003). These fluctuations in salinity may affect crab movement and spatial distribution within the river. For instance, during 2003, a higher than average winter snowfall, followed by a higher than average spring and early summer rainfall resulted in lower than average salinities in the Hudson River. These lower than average salinity recordings were correlated with a lower than average number of crabs captured upriver that season (G. Kenney, personal communication). Wilson and Able (1992) reported that, on average, salinities in the Hudson River were lower than salinities in other areas where blue crabs were studied.

**Figure 1**. Map of the Hudson River salt front location (defined as 100 mg/L chloride concentration) from 1992-2003, from the USGS website

http://ny.water.usgs.gov/projects/dialer_plots/rmmonth_periodofrecord.HTM




Hines (2003) found that hypothermal mortality in lobsters, another decapod crustacean, may be linked with salinity. For example, when intense storm activity resulted in sudden drops in temperature and salinity, lobsters were observed to move to deeper areas in response. In laboratory behavioral preference assays, lobsters were also found to actively avoid salinities below 17-20 ppt (Jury et al. 1995, Jury et al. 1994). It is expected that lower salinities may influence blue crab distribution and movement as well, particularly within the Hudson River estuary (Normandeau 2004). It is presently unknown how this behavioral response may interact with temperature.

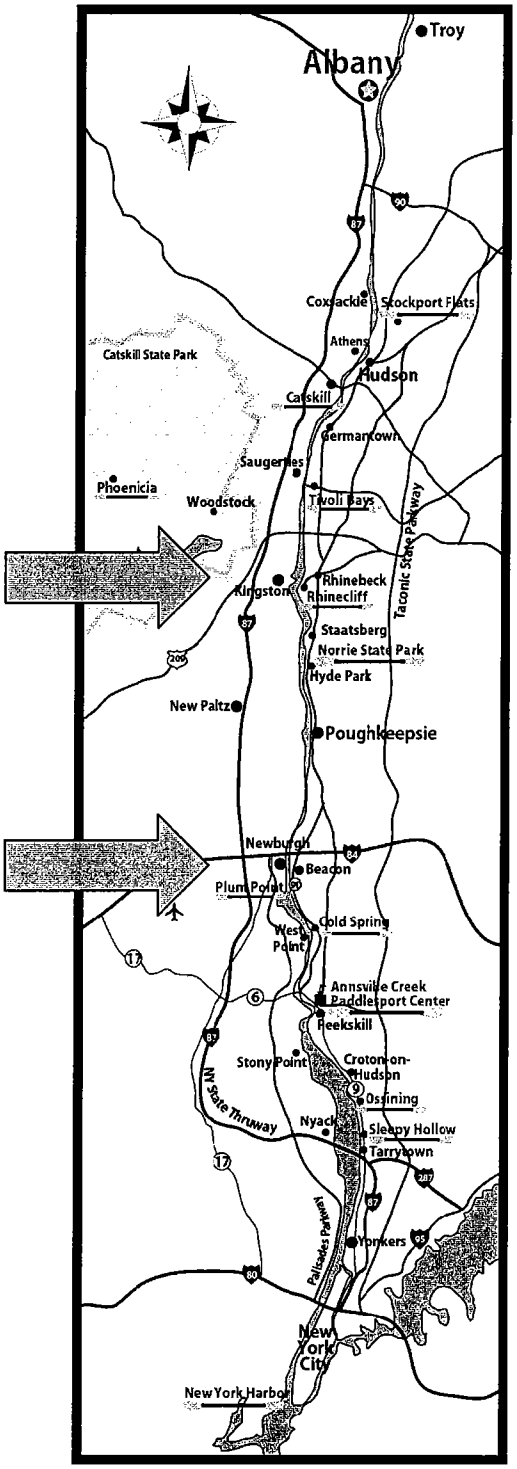
Blue crabs might move within the estuary to increase habitat suitability in such a way as to maximize growth, reproduction, and survival (Aiken 1977, Aiken and Waddy 1986). Other factors that have been shown to impact crab movement are light cues, endogenous rhythms, pH of the water, ionic composition of the water, dissolved oxygen, and presence or absence of food (Wilson and Able 1992, Laird and Haefner 1976).

At present, the movement of blue crabs within the Hudson River is not well understood (Wilson and Able 1992, Normandeau 2004, Stehlik et al. 1998). The purpose of this project was to investigate the effects of salinity at two different temperatures on the adult male blue crab in laboratory behavioral assays. If blue crabs express a preference for a particular salinity, then blue crabs may detect salinity differences and that may subsequently influence their movements (Jury and Watson 2000, Dufort et al. 2001).

## METHODS

Adult male blue crabs (carapace width from base of spine to base of spine 79-130 mm; Hill et al. 1989) were captured in early July 2004 from two upper estuarine sites on the Hudson River (near Newburgh and Kingston; Figure 2). Only male crabs were used in this study because female crabs were not captured in sufficient quantity at either of the two capture sites. On the day of capture, the Newburgh site salinity was 0.27 ppt, and the Kingston site salinity was 0.12 ppt. The water temperature at both sites of capture was 24°C. Both salinity and temperature at each collection site was determined using a YSI 85 handheld digital water quality instrument.

**Figure 2**. Map of Hudson River, Newburgh (RM 60) and Kingston (RM 92) capture sites. (http://www.atlantickayaktours.com/Pages/SubPages/Hudson-River/Hudson-River-Map.shtml)



Blue crabs were captured and held for at least 14 days (acclimation time in accordance with Carter and Fraser 1991, Laird and Haefner 1976) prior to testing in a wetlab at SUNY-New Paltz in solitary compartments in three separate holding tanks in dechlorinated tapwater prepared with artificial ocean seasalts (Instant Ocean) and treated with an anti-ammonia agent (Ammo-lock). The salinity of the reconstituted seawater was measured by a temperature compensated refractometer. The light/dark cycles were controlled to mimic the seasonal light patterns at the time of capture, with a 14L:10D cycle with daylight beginning at 0600. For the purposes of filming nighttime activity with an infrared camera, red lighting was employed during the dark cycle to facilitate image capture. Red lighting was used because crustaceans are generally insensitive to red light (Ali 1984, Autrum 1979); red light was therefore not expected to influence the behavior of blue crabs.

The conditions of the three holding tanks were as follows (Table 1):

**Table 1. Crab acclimation conditions**

| | |
|---|---|
| 1. Low salinity (5 ppt) | Warm temperature (24.5±0.7°C) |
| 2. Low salinity (5 ppt) | Low temperature (18.1±0.6°C) |
| 3. High salinity (20 ppt) | Warm temperature (24.5±0.7°C) |

The "warm" acclimation temperature of 24°C was selected because it was the temperature of the water at the time of crab capture, and it is also typical of summer water temperatures at Newburgh and Kingston (Kenney, personal communication). Although winter water temperatures are significantly lower (0-10°C), crabs are largely inactive at those temperatures (Carter and Fraser 1991). In order to increase the likelihood that crabs would be active in this study, a "cold" acclimation temperature of 18°C was selected. Unfortunately, because one chiller malfunctioned, no crabs were

acclimated to low temperature and high salinity conditions. Therefore, no low temperature/high salinity trials were conducted. Warm-temperature adapted crabs were held in water temperatures at 24.5°C±0.7, however, the water in the salinity chambers during their trials was equilibrated with ambient room temperatures (22-25°C).

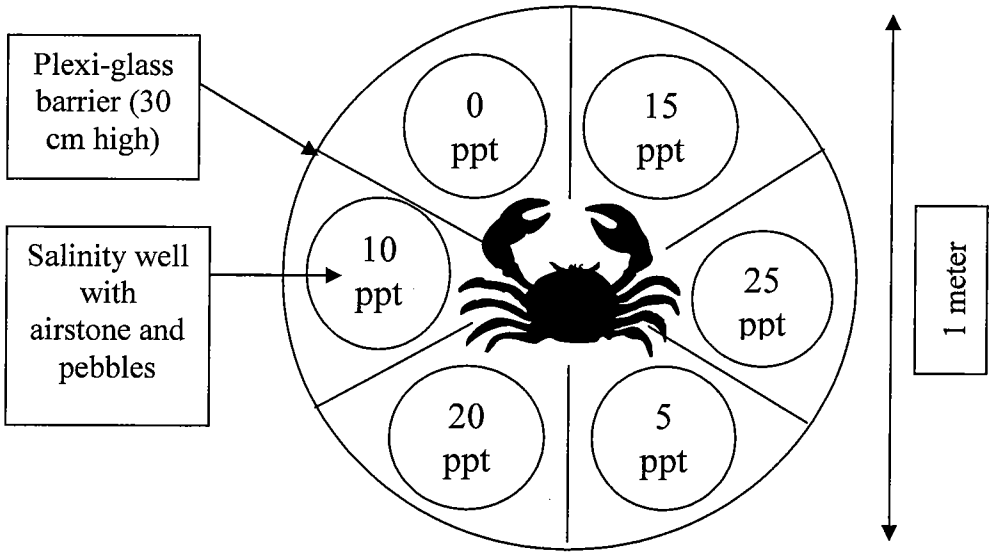
Although the measured salinities at the time of capture were 0.12 ppt and 0.27 ppt at Kingston and Newburgh, respectively, 5 ppt was selected as the "low" acclimation salinity because it represents an average summer salinity at the Newburgh site and 20 ppt was selected as the "high" acclimation salinity because it represents the more brackish salinities found at downriver sites (Wilson and Able 1992).

Adult male blue crabs were fed a diet *ad libitum* of frozen or pelletized shrimp every other day prior to a trial. Crabs were not fed during the trial period (48 hours). Crab feeding history and activity were used as a relative measure of viability. Only viable crabs were selected for trials. Crabs demonstrating no appetite and lethargy were assumed to be unhealthy. In fact, those crabs usually molted or died within one week from the initial observation of lethargy.

Two different styles of salinity preference tanks were used. The six-well tank design employed initially was based on a tank used by Davenport and Wankowski (1973) to study salinity preference in intertidal Porcelain crabs. The salinity tank was constructed by placing six circular bowls, each approximately 15 cm in diameter and 8 cm deep and containing 1 kg of flat, black, 30 mm diameter pebbles, spaced evenly apart along the perimeter of a 1 m diameter pool (Figure 3). Each bowl contained water of a different salinity, ranging from 0 ppt to 25 ppt in increments of 5 ppt. A plexi-glass sheet with holes corresponding to each bowl was placed on top of the six bowls such that it

formed a platform flush with the lip of each bowl. The platform enabled crabs to move from one bowl to another but required brief emersion to get between bowls. This readiness to move via emersion, demonstrated by twelve out of fifteen blue crabs during preliminary trials, is not known to have been previously reported. Plexi-glass barriers approximately 30 x 30 cm separated each well along the perimeter, and prevented trial subjects from moving from one well to another without moving through the center of the tank. A wire barrier approximately one meter high surrounded the entire tank and prevented crabs from leaving the tank area. The wire barrier was covered with opaque plastic to eliminate sources of directional light which might affect crab movement within the tank, and the tank was placed directly underneath an overhead light. Each bowl was continuously aerated with a single airstone connected to an air pump.

**Figure 3. Six-well salinity tank.**




At the start of each trial period, an individual crab was placed within the salinity tank on the platform in the center of the tank, equidistant from all bowls. Trials began at 1800h. Crabs were allowed an initial 24-hour period to acclimate to the tank conditions. Crab movement and the length of time spent in each bowl were recorded during the

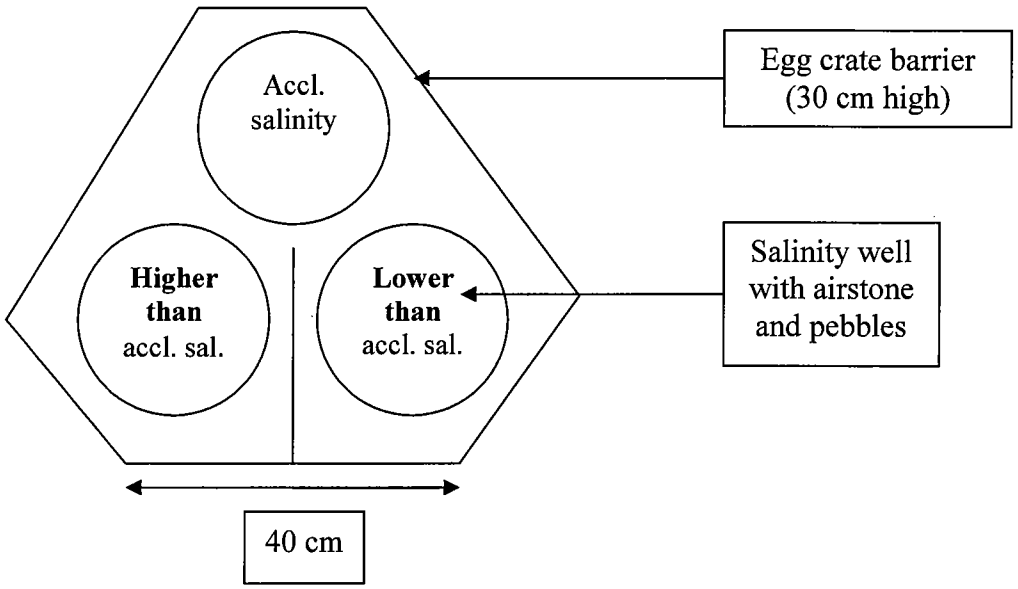
second 24-hour period with an infrared camera and a time lapse digital recorder. After each trial period ended, the water in each bowl was drained, the bowl and pebbles were rinsed, and bowls were refilled with freshly prepared water. The order of placement of bowls was randomized. During the trials in the 6-well tank, three crabs were tested more than once due to limited crab availability. Data from crabs that did not show emersion during the second day of the trial period (n= 7) were omitted from analysis.

Paired control preliminary trials (n=2) were also conducted. In the control trials, all of the bowls contained water of the same salinity (5 ppt) and temperature (24°C) to which the crab had been acclimated during the initial 14 days. Crab movements between wells and the length of time spent in each well were recorded.

In the 6-chambered circular tank only a few crabs (n=3) sampled all six wells during the trial period. Crabs did demonstrate emersion, but some only visited three (n=2), four (n=2) or five (n=3) of the potential choices during the trial period. Thus, because of the potential artifact of crabs not sampling all six wells, a new, simplified design with only two choices was developed.

The modified three-well tank offered crabs a well of their acclimation salinity (5 ppt) and two choices of salinities: one higher than and one lower than the acclimation salinity (Figure 4). A barrier was placed between the high and low choice, so that the crab was forced to return to the acclimation salinity before making another choice. The placement of the higher and lower choice was random.

**Figure 4. Three-well salinity tank.**




Individual crabs were placed in the bowl containing water of the acclimation salinity and temperature at the start of the trial. Five separate trials were conducted simultaneously. As in the 6-chambered tank, bowls were aerated with a single air stone connected to an air pump, 1 kilogram of flat, black pebbles were placed at the bottom of each bowl to facilitate crab movement, a barrier prevented crabs from exiting the tank, and the barrier was covered with a non-transparent plastic material to block directional sources of lighting. Likewise, crabs were allowed an initial 24-hour period to acclimate to the tank conditions, and the second 24-hour period was used for data analysis. In between each trial, bowls were drained, rinsed and refilled.

Paired control and experimental trials (n=17) were conducted for individual crabs under both low (n=12) and high (n=5) salinity-acclimation conditions. Crabs used in the paired trials were placed back into their holding tanks between trials for feeding before the subsequent trial.

## RESULTS

*Trials in the 3-chambered salinity tank*

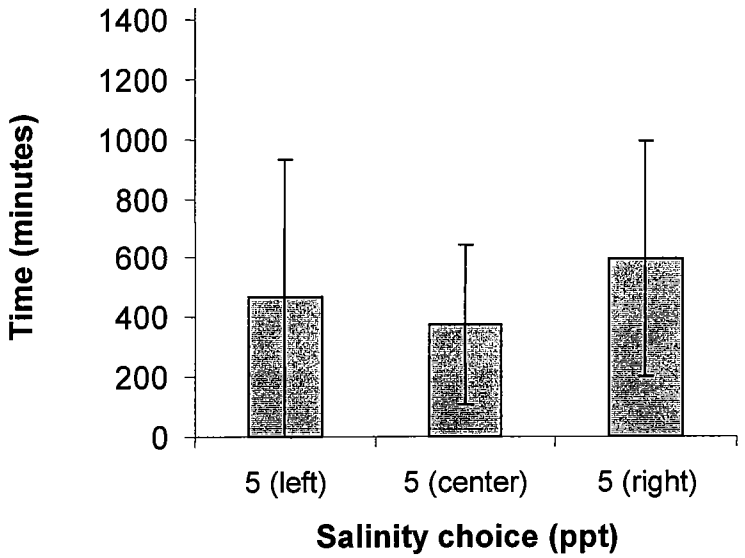
1. *High temperature/low salinity-acclimated crabs, paired control and experimental (0-5-10 ppt) trials*

During control trials, with crabs acclimated to 5 ppt and 24°C, there was no significant difference in the amount of time spent in each bowl ($P>0.10$) (Table 2, Figure 5).

**Table 2. Control trials. Number of minutes in each well, mean and standard deviation.**

| Subject # | 5 (left) | 5 (center) | 5 (right) |
|---|---|---|---|
| 1 | 1440 | 0 | 0 |
| 2 | 814 | 278 | 348 |
| 3 | 411 | 52 | 977 |
| 4 | 29 | 590 | 821 |
| 5 | 73 | 216 | 1151 |
| 6 | 570 | 153 | 717 |
| 7 | 24 | 781 | 635 |
| 8 | 11 | 289 | 1140 |
| 9 | 731 | 630 | 79 |
| 10 | 520 | 550 | 370 |
| 11 | 0 | 725 | 715 |
| 12 | 984 | 234 | 222 |
| **Mean** | **467.3** | **374.8** | **597.9** |
| **St. Dev.** | **466.1** | **267.2** | **393.7** |

**Figure 5. Control trials. Mean +/- standard deviation. Number of minutes in each well, n=12.**



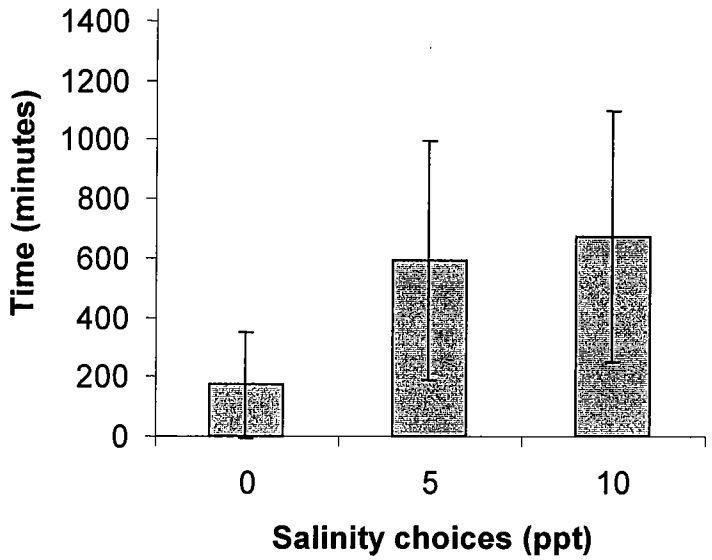

These same crabs were then given a choice of high (10 ppt) or low (0 ppt) salinity in experimental trials (Table 3).

**Table 3. Experimental 0-5-10 ppt trials. Number of minutes in each well, mean and standard deviation.**

| Subject | 0 | 5 | 10 |
|---|---|---|---|
| 1 | 129 | 968 | 343 |
| 2 | 106 | 518 | 816 |
| 3 | 169 | 1172 | 99 |
| 4 | 204 | 1024 | 212 |
| 5 | 160 | 987 | 293 |
| 6 | 0 | 129 | 1311 |
| 7 | 49 | 679 | 712 |
| 8 | 12 | 75 | 1353 |
| 9 | 59 | 875 | 506 |
| 10 | 519 | 203 | 718 |
| 11 | 140 | 149 | 1151 |
| 12 | 544 | 351 | 545 |
| **Mean** | **174.3** | **594.2** | **671.6** |
| **St. Dev.** | **178.4** | **404.6** | **422.3** |

Under these conditions, crabs spent significantly more time ($P<0.01$) in 5 ppt (45%) and 10 ppt (45%) than in 0 ppt (10%) (Figure 6). There was no significant difference between 5 ppt and 10 ppt.

**Figure 6. Experimental 0-5-10 ppt trials. Mean +/- standard deviation. Number of minutes in each well, n=12**



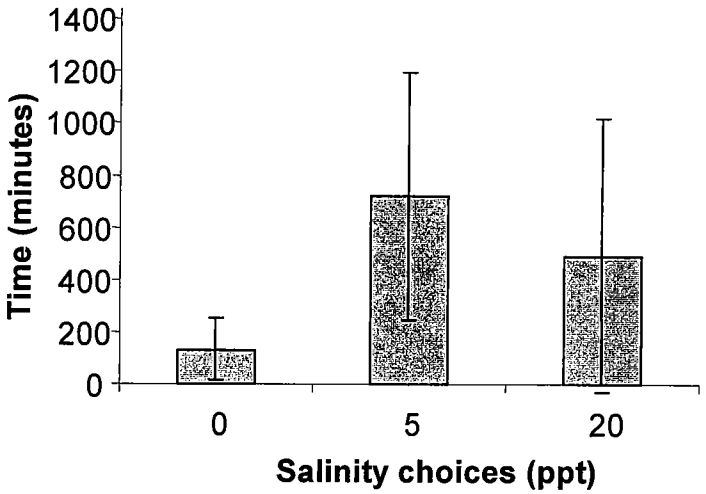

*2. High temperature/low salinity 0-5-20 ppt trials*

Because crabs selected the higher-than-acclimation salinity choice over the lower salinity choice in the set of trials described above, the higher salinity choice was doubled to determine if crabs would differ in their preference. When given an even higher salinity option, crabs (n=14) still selected 5 ppt and the higher salinity choice (20 ppt) over 0 ppt ($p<0.01$) (Table 4, Figure 7). There was no significant difference between 5 ppt and 20 ppt.

**Table 4. Experimental 0-5-20 ppt trials. Number of minutes in each well, mean and standard deviation.**

| Subject | 0 | 5 | 20 |
|---|---|---|---|
| 1 | 269 | 1102 | 69 |
| 2 | 43 | 1265 | 132 |
| 3 | 17 | 519 | 904 |
| 4 | 202 | 1214 | 24 |
| 5 | 168 | 931 | 341 |
| 6 | 274 | 595 | 571 |
| 7 | 19 | 741 | 680 |
| 8 | 309 | 874 | 257 |
| 9 | 197 | 1200 | 43 |
| 10 | 0 | 0 | 1440 |
| 11 | 242 | 21 | 1177 |
| 12 | 0 | 0 | 1440 |
| 13 | 241 | 1199 | 0 |
| 14 | 15 | 1134 | 291 |
| **Mean** | **133.1** | **720.0** | **492.6** |
| **St. Dev.** | **119.5** | **474.9** | **522.6** |

**Figure 7. Experimental 0-5-20 ppt trials. Mean +/- standard deviation. Number of minutes in each well, n=14**



*3. High salinity/high temperature 5-20-30 ppt trials*

Of crabs acclimated to high temperatures (25°C) and high salinities (20 ppt) (n=10), only five crabs survived long enough to be tested. Four of the five crabs either died during the trial period or shortly thereafter and those crabs did not demonstrate emersion. The single surviving crab showed emersion during both control (where all wells contained 20 ppt) and experimental (5-20-30 ppt) conditions. Under control conditions, the crab spent 90% of the time in one bowl. Under trial conditions (5-20-30 ppt), the crab spent 50% of the time in 30 ppt, 19% of the time in 20 ppt, and 30% of the time in 5 ppt. Due to the low sample size, it was not possible to ascertain a salinity preference for this treatment. Note that this group of crabs had a higher mortality rate (90%) than either of the two other acclimation groups.

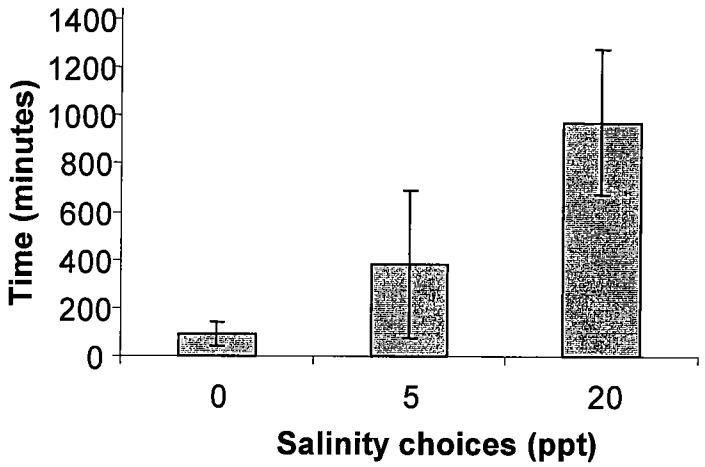
*4. Low salinity/low temperature 0-5-20 trials*

Of crabs acclimated to low salinity and low temperatures (n=14), seven crabs died before they could be tested. Of the crabs tested, three crabs did not show emersion during the trial. The remaining crabs (n=4) showed no significant preference for the acclimation salinity (5 ppt) over 0 ppt ($p>0.05$), but there was a significant preference for 20 ppt over 0 ppt ($p<0.01$). The results ($p<0.01$) suggest that these crabs also preferred the higher salinity choice over 0 ppt (Table 5, Figure 8).

**Table 5. Experimental 0-5-20 ppt cold trials (18°C). Number of minutes in each well, mean and standard deviation.**

| Subject | 0 | 5 | 20 |
|---|---|---|---|
| 1 | 49 | 64 | 1327 |
| 2 | 57 | 785 | 598 |
| 3 | 147 | 259 | 1034 |
| 4 | 111 | 408 | 921 |
| **Mean** | **91.0** | **379.0** | **970.0** |
| **St. Dev.** | **46.4** | **305.1** | **301.3** |

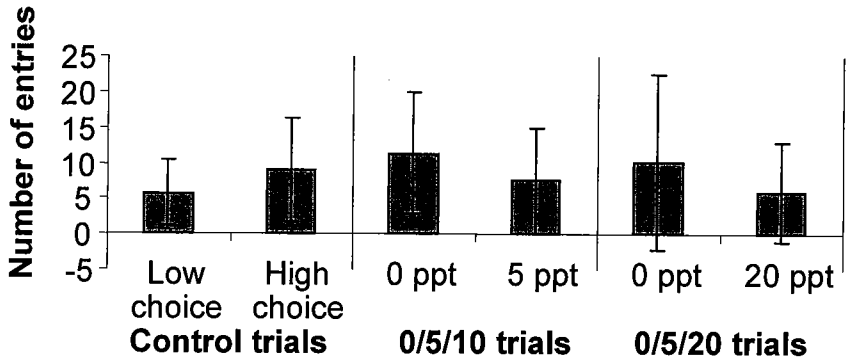
**Figure 8. Experimental 0-5-20 ppt cold trials (18 C) Mean +/- standard deviation. Number of minutes in each well, n=4.**




*6. Crab entries per well*

Crab entries into either the higher-than-acclimation salinity or lower-than-acclimation salinity choices were analyzed to determine if the number of entries into a particular well correlated with the amount of time spent in the well. For paired control ($P>0.10$), 0-5-10 ppt ($P>0.10$), and 0-5-20 ppt ($P>0.05$) trials, there was no significant difference in the number of entries into either well choice (Figure 9).

**Figure 9. Average number of entries per well for control trials, 0/5/10 trials and 0/5/20 trials (N=34)**




## DISCUSSION

The results of this study suggest that adult male blue crabs from the Hudson River select salinities of 5 ppt, 10 ppt, and 20 ppt over 0 ppt at 24°C, even though the crabs were captured at nearly 0 ppt and 24°C. This behavior suggests that crabs may be capable of detecting salinity differences, as reported for other decapods (Dufort et al. 2001) and that their movements may be influenced by salinity preferences. There may be a preference for higher salinities as temperature decreases, and if so, that preference could at least partially explain crab movement downriver during the late fall and early winter months. However, there was no significant difference in the number of entries into either the higher-than or lower-than acclimation salinity wells, thus it is unclear at this time how salinity preference may be manifested in the field.

In this study, crabs showed 90% mortalities when placed in 20 ppt at 24°C, and 50% mortalities when placed in 5 ppt at 18°C. The high mortality rates could have been the result of osmotic stress or temperature stress. The availability of crabs and the limit

of one summer for this project did not permit a more systematic study of the effect of transition period. This type of survivorship study (McCleese 1956) is currently being carried out by Dr. Thomas Miller (Chesapeake Biological Laboratory, University of Maryland) on Hudson River and Chesapeake Bay blue crabs and may provide insight on blue crab survivorship in low temperature and low salinity conditions relative to overwintering behavior.

If crabs prefer higher salinities when water temperatures drop, that could partially explain the lack of crabs found north of Hudson river mile (HRM) 0 in the winter months (Normandeau 2004). Higher water temperatures in the late spring and early summer may result in male crabs moving upriver into lower salinities. This upriver migration could also be the result of other factors, such as availability of food and competition for territory (Wilson and Able 1992), reduced predation (Wilson and Able 1992), reduced susceptibility to disease (Messick and Sindermann 1992), or a behavioral adaptation to optimize conditions for maximum growth during molting (Fisher 1999, Micheli and Peterson 1999). Whatever the reason, male blue crabs predominate in lower salinity waters in this estuary (Wilson and Able 1992).

While fluctuations in salinity within the Hudson River are common (Wilson and Able 1992), it is presumed that crabs are not commonly exposed to the types of stepped changes in salinity as presented in this lab study. This method of testing may have resulted in abnormal behavior of the blue crab relative to salinity gradients found in the natural environment, but did allow us to determine responses to large changes in salinity in a systematic manner. Gunter (1961) noted that fresh water had an anesthetizing effect on the blue crab, and Gleeson et al. (1997) noted that chemosensory function in blue

crabs was significantly lowered by a five-minute exposure to reduced salinity as dendrites of olfactory neurons were shortened. Therefore, the stepped testing method may have created artifact that would not be evident in crabs in their natural environment.

In summary, adult male blue crabs from the Hudson River in this study selected salinities of 5 ppt, 10 ppt, and 20 ppt over 0 ppt at 24°C. Crabs also showed high mortality rates when placed in 20 ppt at 24°C (90%) and 5 ppt at 18°C (50%). Future studies will also address salinity preferences of crabs acclimated to low temperature and high salinity and survivorship at various combinations of temperature and salinity.

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