Classroom survival of native signal crayfish *(Pacifastacus leniusculus)* and non-native red swamp crayfish *(Procambarus clarkii)* in Washington State

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Background

Crayfish are valuable laboratory organisms for elementary through high school students and are suggested or required for a number of science curricula, but the risk of release of non-native crayfish by students or teachers has led to an interest in substituting native crayfish into biological supply in the Pacific Northwest region. In addition, state wildlife regulations prohibit a number of common non-native crayfish used in biological supply, creating an urgent need to find non-prohibited replacement organisms. Washington has a single native crayfish (the signal crayfish *Pacifastacus leniusculus*) that is also commercially harvested as a food species, and as a result regional biological supply companies will be able to provide this species to schools. Developing a supply chain of native crayfish that can meet the needs of Washington schools, including desirable sizes of crayfish and timing of availability, is an important ongoing project. However, the survival, behavior, and general suitability of this crayfish in the classroom must be evaluated prior to transitioning to statewide use of native crayfish.

This document reports on the findings of two studies that evaluated the viability of the Pacific Northwest's native signal crayfish *Pacifastacus leniusculus* as a biological supply organism, focusing on assessing classroom survivorship in comparison to non-native red swamp crayfish *Procambarus clarkii*.

Native signal crayfish

Non-native red swamp crayfish

Study 1

During the summer of 2010, the University of Washington's Summer Institute in the Life Sciences (SILS), a teacher training and continuing education program, compared survival and behavior between the common non-native red swamp crayfish *Procambarus clarkii* and *P. leniusculus*. Participants in this program reported roughly comparable mortality between *P. leniusculus* (5 mortalities of 14 crayfish for 35% mortality) and *P. clarkii* (3 mortalities of 12 crayfish for 25% mortality) over a month of laboratory use under the same conditions (crayfish retained in 2-3 gallon plastic containers in city tapwater with weekly water changes but without aeration). In addition, participants noted that *P. leniusculus* seemed less aggressive than *P. clarkii* and reported that the native crayfish was easy to handle and observe. Important to survival results, *P. leniusculus* in this evaluation were collected from a Seattle area lake and transported directly to the classroom without shipment out of water, the most common delivery method of crayfish to schools.

Study 2

The University of Washington in cooperation with the Pacific Education Institute and Washington Sea Grant conducting a study during the 2010/2011 school year to evaluate the feasibility of using native crayfish in the classroom. We solicited help from school districts and teachers across western Washington to use both native and non-native crayfish in the classroom and determine if the survival and behavior of *P. leniusculus* in the classroom is equivalent or even superior to the survival and behavior of non-native *P. clarkii.*

Methodology

The research study compared survival of native to non-native crayfish in the classroom.
The Pacific Education Institute helped coordinate the study between University of Washington researchers (Eric Larson, Julian Olden), school district administrators, and teachers involved in the study. The aim is to have an adequate number of participants to allow for a reasonably large assessment of native crayfish in the classroom, incorporating diverse experiences and needs of teachers and districts across grades and curricula. Crayfish were made available to schools through a regional biological supply company, Mountain Home Biological. As the intent of the study is to compare native to non-native crayfish in the classroom, we aimed to have one-half of the classrooms involved in the study to use the non-native red swamp crayfish, available through a number of biological supply companies. Use of non-native red swamp crayfish was permitted statewide through the 2010/2011 school year with a temporary permit from the Washington Department of Fish and Wildlife. Teachers recorded performance of crayfish (both species) in the classroom using the provided research protocol and data sheet. Data collection include: species used, arrival date in the classroom, classroom conditions (container type, room temperature, aeration, frequency of water changes), daily survival status, and notes on crayfish behavior and suitability for science curricula (curricula used should be noted). Data sheets were returned electronically or by snail mail. Complete protocols and data sheets are available from Julian Olden.

Results

Participating School Districts (and # teachers): Tacoma (17 teachers), Renton (8 teachers), Mukilteo (4 teachers), Chimacum (2 teachers), Peninsula (1 teacher)

Native *P. leniusculus* were assigned to 19 teachers and *P. clarkii* to 12 teachers.

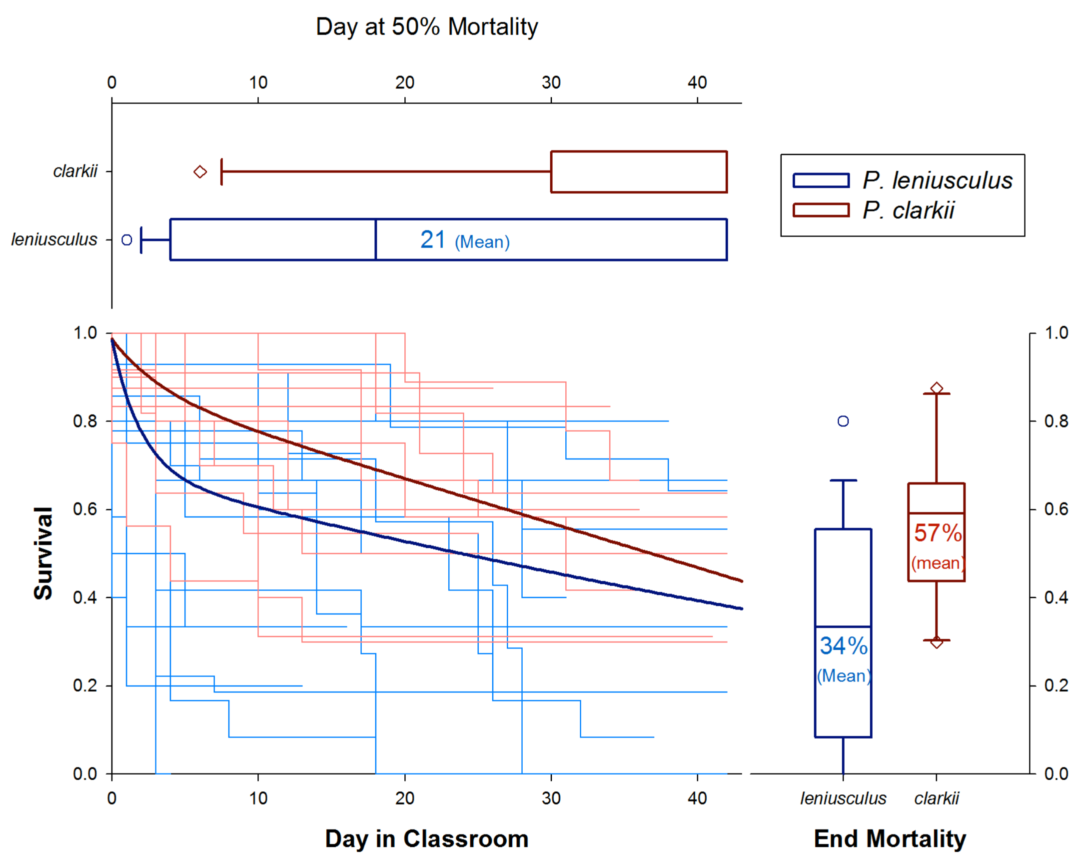
Classroom Survival

Pacifastacus leniusculus had greater mortality than *Procambarus clarkii*, reaching 50% mortality around three weeks with a final mortality rate at the end of use averaging 34% compared to 57% for *P. clarkii.* In particular, *P. leniusculus* had substantially higher mortality immediately following arrival in the classroom (Figure 1; exponential decay lines), leading us to suspect a considerable portion of *P. leniusculus* mortality was attributable to shipping-related stress (see shipping study results). This may not be applicable if crayfish were first received, held, and then redistributed from a science distribution center (see science distribution center section below).

Occasionally, *P. leniusculus* experienced complete (100%) mortality within the first several days of arriving in the classroom, an event than never occurred for *P. clarkii. Procambarus clarkii* mortality was more steady over time. Teacher notes indicated *P. clarkii* mortality was often caused by cannibalism following molts, particularly over weekends when teachers were not present to separate recently molted crayfish from others in tanks (see weekend section below). In most cases, the rate of *P. leniusculus* mortality slowed after the first several days in the classroom, with some exceptions in which a steady rate of mortality persisted throughout classroom use.

Variation in survival performance was considerably higher for *P. leniusculus*, indicating potential to improve *P. leniusculus* survival under better shipping or classroom conditions. However, survival of both crayfish species in classrooms was fairly poor, with even *P. clarkii* mean survival at the termination of use at 57 %. Some teachers expressed considerable distress over mortalities. A teacher using *P. clarkii* with 50% survival rate wrote “Am not at all in favor of inhuman conditions we are expected to keep crayfish in for classroom condition. Minimum requirements (living) should at least be met. Science distribution center, not the teacher, should see to that, as well as this study.” Highly variable maintenance of crayfish under classroom conditions is discussed below.

Figure 1. Survival of *Procambarus clarkii* (red) and *Pacifastacus leniusculus* (blue) under classroom conditions represented as individual classrooms (light lines) and average performance plotted as an exponential decay function (dark lines), with box plots of mortality at end of classroom use and day at 50% mortality.



Science Distribution Centers

Our results are predominantly from teacher experiences in the classroom, and not the science distribution centers that in many cases place the initial orders, receive crayfish, and then redistribute crayfish to classrooms. It is likely that in many cases science distribution centers will be exposed to and deal with any initial shipping mortality. For *P. leniusculus*, this can be considerable. As one example, the Renton science distribution center received 48 *P. leniusculus* from Mountain Home Biological on Thursday, October 7th, 2010. By the following morning, only 28 were still alive. Upon returning that Monday following the weekend, only 7 *P. leniusculus* were still alive. The majority of these crayfish survived through the following week. Renton made a re-order through Mountain Home Biological, in which 105 crayfish were received on Tuesday, October 19th. The following day 97 of these crayfish were still alive, and were promptly supplied to classrooms. Renton teachers receiving these crayfish reported total mortality rates of *P. leniusculus* ranging from 20% to 66% over two and a half weeks of use, with most mortality occurring within the first several days of receiving crayfish.

Weekends

While entering data from teachers, a consistent pattern emerged in which most mortality was reported on Mondays following weekends or the first day returning from a holiday. Several explanations for this seem feasible. A crayfish that dies during the weekend will remain in the tank and may worsen water quality for its tank mates, producing additional mortality. A crayfish that molts during the weekend will not be removed to another tank and is more likely to be cannibalized. Or classroom conditions themselves may worsen on the weekend. One teacher writes "During the week the classroom is heated to 73 F and above. On evenings and weekends (including a 4 day weekend due to conference) the classroom gets very cold, around 50 F." Mortality associated with some issues like classroom temperature swings will not be possible to control.

Classroom Conditions

Reporting of classroom conditions was fairly inconsistent, but some conclusions can be reached. Of 31 reporting teachers, none provided filtration in aquariums or containers, and only one reported providing aeration. Teachers are likely utilizing materials in kits or provided by science distribution centers, with little to no modification. Most teachers kept elodea (aquatic plant) in tanks at all times as a potential food resource, and fed canned cat food at frequencies ranging from daily to once a week. It seems that a number of teachers (likely following instructions from science distribution centers) fed crayfish in small tanks separate from their usual containers to minimize water quality issues related to the food; this seems like a good suggestion if use of canned cat food persists, although we question why canned cat food is preferred over fish food. Alternatively, feeding under supervision in a small container inhibits the opportunity for the crayfish to forage independently (e.g., may prefer to feed at night).

Small numbers of teachers reported feeding items including lunch meat, hot dog sections (at the request of students), potato slices, frozen peas, and one reported offering a live goldfish to try and entice crayfish to eat. Teachers and students expressed concern at crayfish that were disinclined to feed, but patterns of crayfish feeding (and activity in general) do not appear evident between *P. leniusculus* and *P. clarkii*. For both species, some teachers reported aggressive behavior and some reported docile behavior (crayfish likely lethargic under low oxygen or food conditions), while some reported active feeding and some reported a failure to feed. It appears that most teachers (particularly for those districts, Tacoma and Renton, where we have the most data) follow a consistent protocol from the science distribution center, with some variation related to word of mouth and discussions with other teachers. Science distribution centers remain a critical nexus to supply reliable information to teachers on care of classroom organisms, although teacher deviations from provided protocols will be inevitable.

For example, frequency of water changes reported by teachers ranged from every day to none reported. Notably, every day water changes may consistently expose crayfish to high levels of water treatment chemicals if not de-chlorinated, while no water changes (in the absences of filtration) has repercussions for water quality and survival.

Developing and communicating best practices for crayfish classroom survival, regardless of species, is needed. We suggest the following in order of feasibility:

EASY

1) Weekly water changes
    - Preferably dechlorinated, at least leaving water exposed to air overnight
2) Minimizing over-feeding
    - Feed every 2-3 days a small volume of a single food type, preferably a commercial fish food

MODERATE

3) Minimize the number of crayfish per container
    - This is only feasible to the extent that supplies are available, but fewer crayfish in a container reduces water quality issues, reduces the likelihood that a crayfish mortality over the weekend will kill tank mates by rotting unchecked for several days, and hopefully reduces likelihood of cannibalism.
    - We suggest that perhaps fewer crayfish per classroom (1 per tank) that are better cared for may reduce mortality and improve classroom experiences. This may also be necessary if improving shipping survival comes with accompanying cost increases.

DIFFICULT

4) Aeration and filtration
    - There is no question that aeration and filtration would likely improve all crayfish (regardless of species) survival under classroom conditions. At present, this equipment is not included in kits or provided by science distribution centers. Some teachers may provide such equipment on their own, but this will not likely be the case. Addition of aeration and filtration also increases the likelihood of escape, further increasing costs (lids) for containers and potentially contributing to additional mortality. Improving classroom welfare (and survival) for organisms is an important long-term goal, but may not be feasible for immediate (school year 2011-2012) implementation. At the district-wide scale, the cost of basic foam biofilters, air pumps, airline tubing, and container lids may be prohibitive.
5) Reduce temperature fluctuations
    - This may be infeasible, but wide daily or weekly temperature swings may be problematic. It is unlikely that teachers (or schools) can control this. Heating or chilling tanks would require equipment, and would also provide opportunities for crayfish to escape (see above). This likely remains an intractable problem regardless of species.
    - Beyond direct mortality from stress, temperature swings may induce molting and related cannibalism.