Ghost Shrimp in Aquaculture

Ghost shrimp found in the Puget Sound. Source: Washington State Department of Ecology.

Content Focus:

- Statistics and Probability

Content Standard:

- CCSS.MATH.CONTENT.HSS.ID.A.2
- CCSS.MATH.CONTENT.HSS.IC.A.1
- CCSS.MATH.CONTENT.HSS.IC.B.4
- CCSS.MATH.CONTENT.HSS.ID.C.8
- CCSS.MATH.CONTENT.HSS.ID.C.8

Mathematical Practices:

- SMP1 - Make sense of problems and persevere in solving them.
- SMP4 - Model with mathematics.

Smarter-Balanced Assessment (SBA) Targets Addressed:

- Claim 2 Target A: Apply mathematics to solve problems arising in everyday life, society, and the workplace.
- Claim 2 Target C: Interpret results in the context of a situation.

Sources Used

[Willapa Bay Mechanical Management of Burrowing Shrimp Supplement, July 2018, WA Dept of Natural Resources]

Overview

The purpose of this 3 ACT task is to provide students with an opportunity to problem solve based on a real-world situation (Target A: Apply mathematics to solve problems arising in everyday life, society, and the workplace. Target D. Identify important quantities in a practical situation and map their relationships). Due to the nature of the task, there are a variety of mathematical approaches students can take to successfully complete the task. It would serve well as an assessment tool at the end of a unit.

Content Focus:

- Statistics and Probability

Content Standard:

- CCSS.MATH.CONTENT.HSS.ID.A.2: Use statistics appropriate to the shape of the data distribution to compare center (median, mean) and spread (interquartile range, standard deviation) of two or more different data sets.
- CCSS.MATH.CONTENT.HSS.IC.A.1: Understand statistics as a process for making inferences about population parameters based on a random sample from that population.
- CCSS.MATH.CONTENT.HSS.IC.B.4: Use data from a sample survey to estimate a population mean or proportion; develop a margin of error through the use of simulation models for random sampling.
- CCSS.MATH.CONTENT.HSS.ID.C.8: Compute (using technology) and interpret the correlation coefficient of a linear fit.

Mathematical Practices:

- SMP1: Problem Solving "Students can solve a range of complex well posed problems in pure and applied mathematics, making productive use of knowledge and problem-solving strategies."
- SMP4: Modeling and Data Analysis "Students can analyze complex, real-world scenarios and can construct and use mathematical models to interpret and solve problems."

Smarter-Balanced Assessment (SBA) Targets

- Target A: Apply mathematics to solve problems arising in everyday life, society, and the workplace.
- Target C: Interpret results in the context of a situation.
- Target D. Identify important quantities in a practical situation and map their relationships (e.g., using diagrams, two-way tables, graphs, flow charts, or formulas).

Overview of task with standard addressed specified

The purpose of this 3 ACT task is to provide students with an opportunity to problem solve based on a real-world situation. The task is modeled after the 3 ACT Fill'er Up by Graham Fletcher. In the task, students are presented with a scenario faced by Washington State aquaculture companies: The native ghost shrimp are destructive to oyster aquaculture efforts in Willapa Bay. Students then decide on necessary resources for finding the solution and are given time as a group to complete their work. The task concludes by having students examine the information provided in Act Three to see if it answers their question.

Learning Goal Statement

- Students will solve a range of complex well-posed problems in applied mathematics (SMP1).
- Students will solve a complex problem by making productive use of knowledge and problem-solving strategies (SMP2).
- Students will analyze complex, real-world scenarios (SMP4).

Success Criteria

- I can apply statistics concepts to interpret a problem about oyster aquaculture. (MP1, MP2)
- I can use statistics to describe a relationship between two quantities related to oyster aquaculture. (MP4)

Step By Step:

1. Materials

- Recording sheet, scratch paper, whiteboards, math journal (if applicable) for each group
- Technology to show videos/PowerPoint
- Student worksheet or notebooks and manipulatives

2. Pre-Planning

- Students will be identifying and solving their own student-generated problems based on the context provided by a hypothetical scenario, and information about ghost shrimp populations.
- Additional information is available to students as they come up with questions through the PowerPoint slides. You may choose to keep it in the PowerPoint format, print each question/answer on cards, or use another method. It is recommended that you not reveal the questions/answers unless students are asking. You can also choose to reveal the answers to specific groups as requested, or to the entire class.
- This lesson will include productive discussion that will open opportunities for multiple possible questions and math concepts. Students may need scaffolded supports or routines for productive discussions.
- Prepare access to materials such as scratch paper, math manipulatives, and other materials as you see fit for use as needed through the task.

3. Act 1 Introduction

- Read the learning goals aloud. Use the Think-Pair-Share strategy to have students respond to the prompt: "What connections or questions come to mind in relation to these learning goals?"
- Orient students to the problem by using one or more of these resources:
  i. Read PEI's Career Profile Card "Senior Shellfish Biologist".
  ii. Read the Seattle Times article from 2015 "Back to the drawing board for control of oyster-killing shrimp" to get the idea of the problem.
  iii. Read small scale oyster farming for pleasure and profit in Washington from WSG.
- Read the student page Introduction to the Problem. (There is a student printout and also a slide)
- Ask students to Think-Pair-Share to answer the following questions: "What is aquaculture of oysters?" "Why and how do ghost shrimp affect oyster aquaculture?" Elicit student ideas.

  Talk to students about the following: Oysters are grown in areas such as Willapa Bay. Oyster farming is a business that keeps people employed and it also generates food for people to eat. Ghost shrimp are a natural part of the environment, but if there are too many then they negatively impact the oyster population.
- Show the first "Scenario" slide.
- Ask students, "What kind of math questions can we answer using this information?" Record student ideas in a public place.
- Allow time for students to come to a consensus around one question generated from the group ideas. You may want each group to explore their own question, or you could have a consensus question for the entire class. Instruct students to analyze the questions generated to determine what information is

needed in order to answer the generated questions. Students should record their question on the group recording sheet.

- Have groups share questions with the class and discuss as a whole group ideas about what information is needed to answer the group's chosen question. Make connections to groups who have posed similar questions. Show the slide, "Aquaculture companies have to maximize profits." Reinforce that these are questions the aquaculture companies are looking to answer. Students are welcome to answer these questions but are encouraged to pursue their own generated questions as long as they stay connected to the facts provided.
    i. Aquaculture companies have to maximize profits. Some of the questions they may ask when replanting an area might be: How do you know the shrimp population? Are there better/quicker/cheaper ways to find the population? Does the dry harrowing method work? How well does it work? How many times do you have to do it to get results? Do the shrimp just move to the non-harrowed areas?
- Prompt students to generate predictions for answers to the questions and post where visible to the class. These can be estimations or qualitative; no calculation is required.

4. Act 2 Conflict

- Ask students, "Do you have everything you need to solve your problem?" Give students time to create a list of materials they will need or questions they have. Let students know that you have answers to common questions (in the PowerPoint slides).
- Show how the Information Card provides the information from the scenario as well as examples of various algebraic strategies. Show students where to find this information.
- Students can use the worksheet, math notebooks, graph paper, whiteboard, or manipulatives to organize and make sense of the data.
- Instruct student groups to record their thinking and math work on the recording sheet and with other materials as needed. Inform students that this work will be collected as evidence of their learning. Consider using FlipGrid or other technology to record student explanations.
- As students are working, be sure to ask questions about their thinking. Take note of different strategies students are using.
- Choose at least three (3) students or groups to share their strategies with the class during ACT 3. Make sure the strategies demonstrate math learning that aligns with learning goals.
- When student groups agree on an answer, instruct groups to answer their question on their group recording sheets.
- Remind students of access to sentence frames on the Information Card for complete responses.
- Students can work with a partner to answer the questions, using their sentence stems.

5. Act 3 Resolution

- Allow at least three (3) students to share their groups' answers with a complete description of how they completed the task. Remind students of access to discussion frames for complete responses. Teacher moves: Pay attention to the solutions created by student groups. Select groups to present their solutions to the class and sequence the groups so they present from "least sophisticated" to "most sophisticated" solution methods.

- Ask questions that allow students to make connections between the different answer statements to the learning goal. For example: How were these approaches similar/different?
- Display the "Resolution" slides that provide answers to the questions from the initial prediction. If a group's question was the same, have students determine possible reasons for any differences between the answers. If a group's question was different, having students determine strategies for the presented solution could have been used to support students in finding the answer to their problem.
- Ask students to rate their learning of the learning goals 0-10 (0 being you made no connection to the learning goals, 10 being you could teach this content) record what they learned.

Accessibility Strategies Used

- Scratch paper or white boards: Students can use blank paper to record thinking, complete calculation, create diagrams, etc.
- Manipulatives: Students can use any math manipulatives to support their problem solving.
- Print the information cards so students can look at the graphs closely.

Things to Consider

- The lesson can take different paths depending on the student questions generated. Use this as an opportunity to reteach or extend different math concepts.
- There is opportunity for differentiation with intentional grouping of students by skill level, however this is not essential for students to meet the learning targets.
- The lesson can be split into multiple days where students create and find solutions to their questions on the first day and share their responses and discuss solutions on the second day. Different groups can do different problems depending on how the lesson fits into the overall flow.
- This tool could be used in many different ways in the math classroom:
  - as formative assessment pre- or post-instruction,
  - as an opportunity to practice new skills,
  - as practice for state tests, or
  - to help make connections to math in the world outside of the classroom.

Formative Assessment Process

- Clarify learning targets throughout the lesson. This is specifically done at the beginning and end but is helpful at any point to further students' learning.
- Evidence of student learning is found in multiple areas of the lesson. The Group Recording Sheet and individual responses are concrete options. Teacher observations, student questions, and student discussion provide additional evidence of students meeting learning targets.
- Use observations of student thinking and other evidence as an opportunity for purposeful discussions around the math concepts. These can be opportunities to reteach or extend learning of math concepts.
- Feedback based on evidence of student learning should be provided to students throughout the lesson. This can happen as the teacher circulates the room, during class discussion, or on group or individual response sheets.

Strategies Used: In-depth look at teaching strategies used in the lesson

- 3 ACT Task
  - This is a whole-group task made up of 3 parts: Act 1 is an engaging situation that piques students' curiosity. Act 2 is where students seek information and work toward a solution, and Act 3 finishes the task by discussing solutions and tying the work back to the learning targets.
- Think-Pair-Share
  - With this strategy, students are given the opportunity to examine a prompt as an individual, then with a partner or small group, and finally sharing and listening to responses among the whole class.
- Notice/Wonder
  - This strategy allows students to unpack a problem or prompt before beginning to solve the problem or respond to the prompt. The purpose is to create a common experience and provide access for all students in an environment where students share their thoughts freely because there is no expectation to find the answer.
  - Find more about the Notice and Wonder strategy on the OER Commons: www.oercommons.org/courseware/lesson/79074/overview?section=1

Samples of Student Work

Coming Soon!

Formative Assessment Rubric

Rubric Components	3	2	1	How to use the rubric
I can make a claim and justify it with mathematics for a solution to determine …	• Described the claim clearly. • Showed the mathematics to back up the solution.		• Claim isn't clear. • Math isn't there or doesn't support the claim.	It is recommended that the teacher refine this language to make it specific to the particular problems and learning goals for the class. Keep language to a minimum to maximize the impact of the feedback to students. Use an arrow to indicate where the student's performance is on the rubric.
I can make a claim and justify it with mathematics for a solution to determine …	• Described the claim clearly. • Showed the mathematics to back up the solution.		• Claim isn't clear. • Math isn't there or doesn't support the claim.	
I can collaborate with others to model an aquaculture problem.	• Respectful of others' ideas • Actively including • Encouraging		• Disrespectful of others' ideas • Actively excluding • Discouraging	

Presentation Materials - PowerPoint Slides

Aquaculture in Willapa Bay

Growing oysters in the presence of ghost shrimp

Slide 1

Learning Goals:

★ Students will solve a range of complex well-posed problems in applied mathematics (SMP1).

★ Students will solve a complex problem by making productive use of knowledge and problem-solving strategies (SMP2).

★ Students will analyze complex, real-world scenarios (SMP4).

Success Criteria:

★ I can apply algebra concepts to solve a problem about oyster aquaculture. (SMP1, SMP2)

★ I can interpret a function that models a relationship between two quantities. (SMP4)

Slide 2

CCSS.MATH.CONTENT.HSS.ID.A.2
Use statistics appropriate to the shape of the data distribution to compare center (median, mean) and spread (interquartile range, standard deviation) of two or more different data sets.

CCSS.MATH.CONTENT.HSS.IC.A.1
Understand statistics as a process for making inferences about population parameters based on a random sample from that population.

CCSS.MATH.CONTENT.HSS.IC.B.4
Use data from a sample survey to estimate a population mean or proportion; develop a margin of error through the use of simulation models for random sampling.

Slide 3

Scenario:

When populations of native ghost shrimp are too high, then it harms the population of oysters.

The problem: Ghost shrimp are a native species that lives in this environment. The ghost shrimp feed by "bioturbation", meaning they shuffle up the sand in search of food. Their search for food causes any baby oysters nearby to be covered by sand and then suffocated. Instead of hard packed sand, which is better for oysters, the bioturbation causes the sand to be very soft, with the texture of quicksand.

Oyster growers did an experiment to see if the "dry harrowing" method would reduce population growth of ghost shrimp enough to use that area of the aquaculture of oysters.

This image shows Willapa Bay, and the plots where the monitoring of shrimp populations occurred.

(source: Willapa Bay Mechanical Management of Burrowing Shrimp WA DNR 2018)

Figure 1. Grassy Island - Willapa Bay WA. Dry Harrow and subsequent control plots in supplemental monitoring study. The dashed line indicates plots DH4 through DH6 - established for supplemental monitoring.

Slide 4

Scenario: Oyster growers did an experiment to see if the "dry harrowing" method would reduce population growth of ghost shrimp enough to use that area of the aquaculture of oysters.

This image is zoomed in to the plots where the monitoring of shrimp populations occurred. Yellow was experimental plots that were dry harrowed and white was the control plots that did not get a treatment.

Slide 5

Aquaculture companies have to maximize profits

There is a cost associated with any treatment to reduce ghost shrimp populations.

As you work through your solution, consider:

How do you know if you have too many ghost shrimp?

How can I determine shrimp populations?

How can I determine the density of populations?

How can I tell if the dry harrowing treatment works? How long does it work?

Slide 6

Problem 1: Notice and Wonder

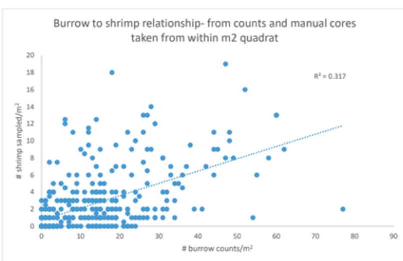


Figure 20. Burrow counts compared with shrimp density collected from within a square meter quadrat (p = 0.001, n= 415).

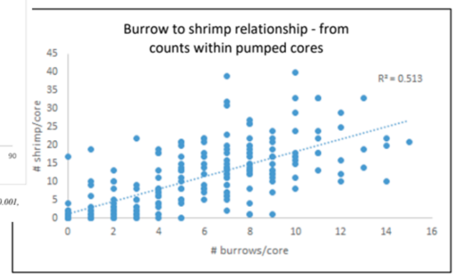


Figure 19. Burrow counts compared with shrimp density collected from within pumped cores (p = 0.001, n=243). Pumped cores were 20 cm diameter or 0.125 m², (1/8m²) in surface area.

Slide 7

Act 1 Problem 1a: Can you look at the surface burrows to determine the underlying shrimp population?

Source: Willapa Bay Mechanical Management of Burrowing Shrimp Supplement July 2018 WA Dept of Natural Resources.

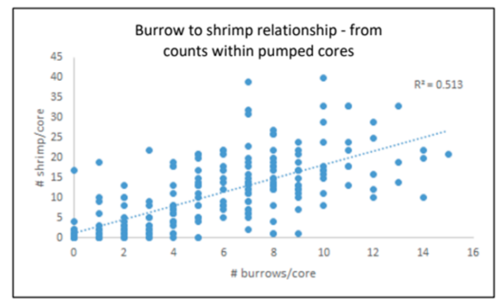


Figure 19. Burrow counts compared with shrimp density collected from within pumped cores (p = 0.001, n=243). Pumped cores were 20 cm diameter or 0.125 m², (1/8m²) in surface area.

Slide 8

Act 1 Problem 1b: Can you look at the surface burrows to determine the underlying shrimp population?

Source: Willapa Bay Mechanical Management of Burrowing Shrimp Supplement July 2018 WA Dept of Natural Resources.

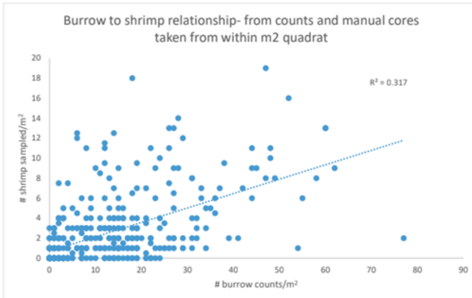


Figure 20. Burrow counts compared with shrimp density collected from within a square meter quadrat (p = 0.001, n= 415).

Slide 9

Act 2 Problem 1

What information do you need to solve your problem?

Slide 10

Act 3 Problem 1: The Reveal

For problem 1a, no. The line of best fit has an r2 value of only 0.513. This means about 51% of the variance in the outcome could be explained by this linear model. In general, with an r2 value this low, the predictions we could make will be too imprecise to be useful.

For problem 1b, the r2 is 0.317, indicating that about 32% of the variance in the outcome is explained by the linear model.

Overall, you need to do either a pumped or manual core to get an accurate determination of the ghost shrimp population. It is more expensive because it takes longer to do it.

Slide 11

Problem 2: Notice and Wonder

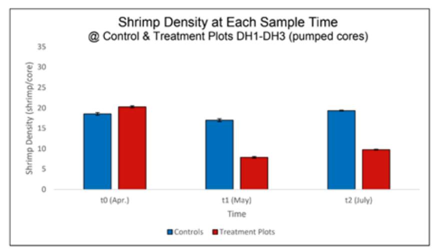


Figure 25. Mean burrowing shrimp density for control and treatment DH1-DH3 plots from POC experiment. Plots dry harrowed with two passes of the roller-chopper, and revisited for monitoring in May and July.

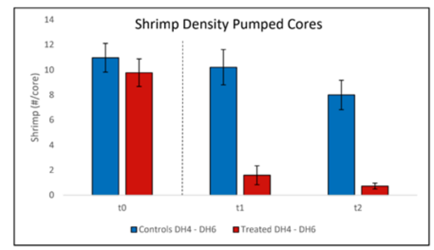
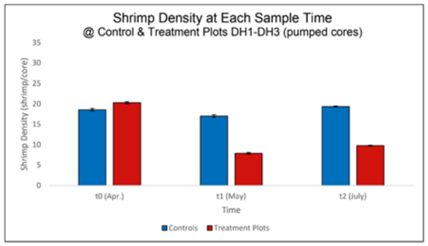


Figure 8. Mean shrimp density collected per pumped core at Control and Treated plots at t0, t1, and (shrimp/0.125m²). Dotted line indicates timing of treatment.

Slide 12

Act 1 Problem 2: How many passes are needed?

Figure 25 shows plots that were dry harrowed twice, and figure 8 shows plots that were dry harrowed four times. The lines on top of each bar indicate the margin of error for the data. Note that no plots had been treated at t0. Source: Willapa Bay Mechanical Management of Burrowing Shrimp, WADNR 2018



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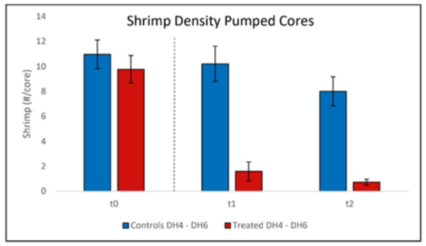


Figure 8. Mean shrimp density collected per pumped core at Control and Treated plots at t0, t1, and t2 (shrimp/0.125m²). Dotted line indicates timing of treatment.

Slide 13

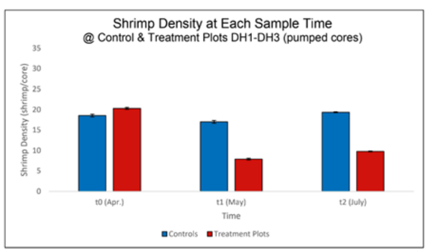
Act 2 Problem 2: How many passes are needed?

What else do you need to know to solve your problem?

Slide 14

Act 3 Problem 2: How many passes are needed?

Answer: Two passes gives a significant reduction in the ghost shrimp population, while four passes reduces it even more. If there is the time and money to do it four times, then do it. If there is only time or money for 2 passes, it is still very helpful.



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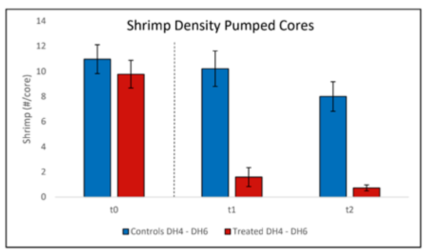


Figure 8. Mean shrimp density collected per pumped core at Control and Treated plots at t0, t1, and t2 (shrimp/0.125m²). Dotted line indicates timing of treatment.

Slide 15

Problem 3: Notice and Wonder

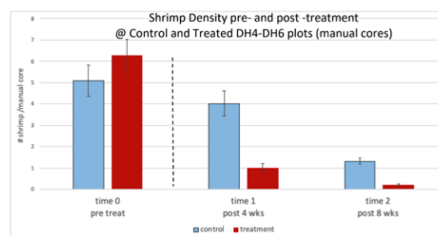


Figure 12. Mean shrimp density collected by manual core in Control and Treated plots at t0, t1, and t2. Dashed line indicates relative timing of treatment.

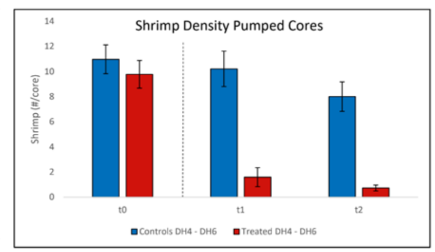


Figure 8. Mean shrimp density collected per pumped core at Control and Treated plots at t0, t1, a (shrimp/0.125m²). Dotted line indicates timing of treatment.

Slide 16

Act 1 Problem 3: Are pumped cores as accurate as manual?

These graphs are both about the measurements taken at the same time on the same treatment plots. Source: Willapa Bay Mechanical Management of Burrowing Shrimp, WADNR 2018

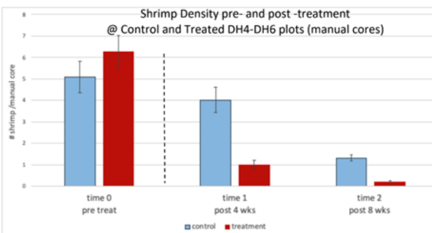


Figure 12. Mean shrimp density collected by manual core in Control and Treated plots at t0, t1, and t2. Dashed line indicates relative timing of treatment.

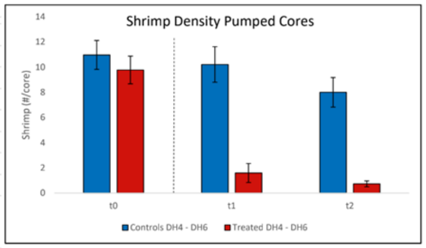


Figure 8. Mean shrimp density collected per pumped core at Control and Treated plots at t0, t1, and t2 (shrimp/0.125m²). Dotted line indicates timing of treatment.

Slide 17

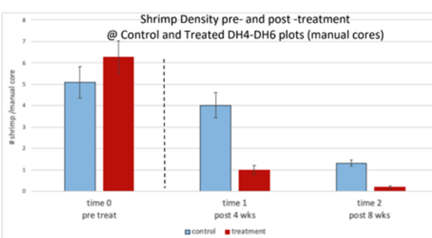
Act 2 Problem 3: Are pumped cores as accurate as manual? Because they are quicker and cheaper!

What additional information do you need to solve your problem?

Slide 18

Act 3 Problem 3: Are pumped cores as accurate as manual?

No, they are not as accurate. In these graphs, pumped cores appear to be overestimating. However, it seems like they are similar enough that pumped cores could work if there is a shortage of time/$ to do the measuring work. It is a good idea to do a mixture of sampling types to balance the time/cost with the accuracy needed to make good decisions.



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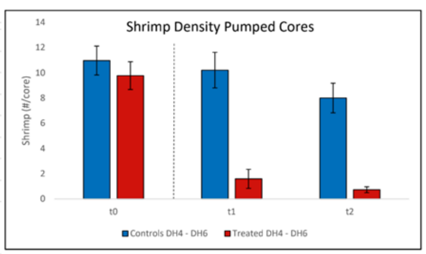


Figure 8. Mean shrimp density collected per pumped core at Control and Treated plots at t0, t1, and t2 (shrimp/0.125m²). Dotted line indicates timing of treatment.

Slide 19

Problem 4: Notice and Wonder

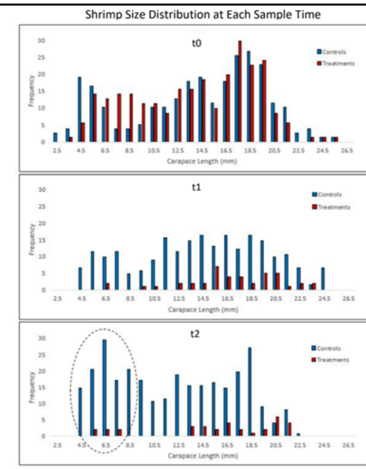


Figure 14. Carapace lengths (CL) for treated and control plots - shrimp at t0, t1, and t2 collected from pumped density cores for plots DH4, DH5 and DH6. An increase in the magnitude of the extra small class can be seen within circled region at t2.

Slide 20

Act 1 Problem 4: How did size of shrimp change after treatment compared to control?

Source: Willapa Bay Mechanical Management of Burrowing Shrimp, WADNR 2018

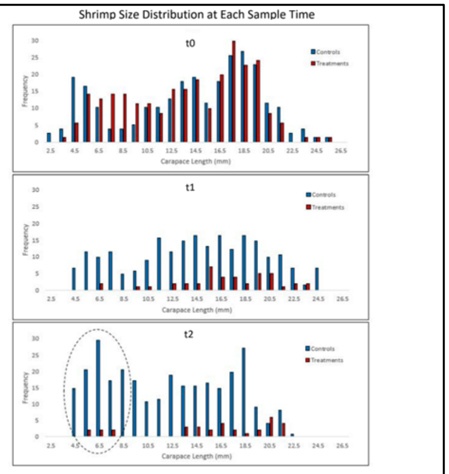


Figure 14. Carapace lengths (CL) for treated and control plots - shrimp at t0, t1, and t2 collected from pumped density cores for plots DH4, DH5 and DH6. An increase in the magnitude of the extra small class can be seen within circled region at t2.

Slide 21

Act 2 Problem 4: How did size of shrimp change after treatment compared to control?

What else do you need to know to solve your problem?

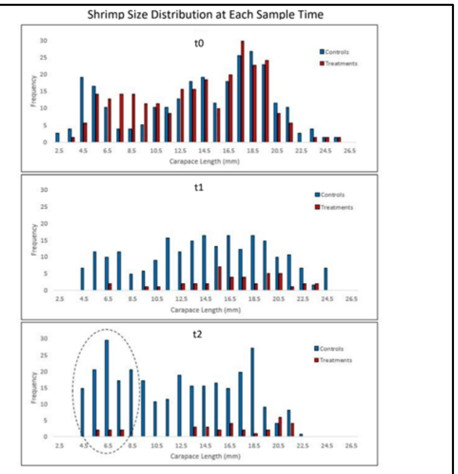


Figure 14. Carapace lengths (CL) for treated and control plots - shrimp at t0, t1, and t2 collected from pumped density cores for plots DH4, DH5 and DH6. An increase in the magnitude of the extra small class can be seen within circled region at t2.

Slide 22

Act 3 Problem 4: How did size of shrimp change after treatment compared to control?

Answer: All sizes of shrimp were reduced. If there was already a small population of that particular size before treatment, then after treatment the population went down a lot. Shrimp 16.5mm and larger were greatly reduced. By t2, some of the very smallest sized shrimp were growing back in the treated areas. Also by t2, the largest sized shrimp in the control group are also gone for some unknown reason.

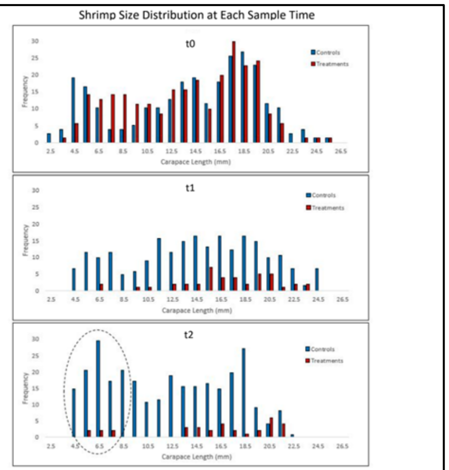


Figure 14. Carapace lengths (CL) for treated and control plots - shrimp at t0, t1, and t2 collected from pumped density cores for plots DH4, DH5 and DH6. An increase in the magnitude of the extra small class can be seen within circled region at t2.

Slide 23

Problem 5: Notice and Wonder

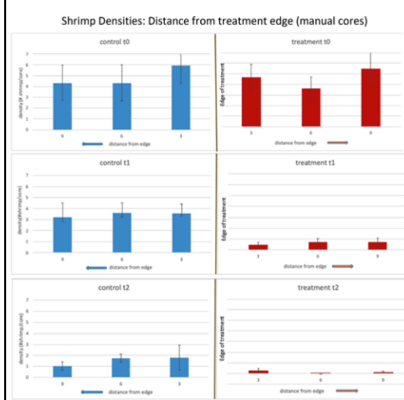


Figure 18. Mean shrimp densities from manual cores along a distance gradient from treatment edge, at times t0, t1 and t2. Error bars indicate standard error.

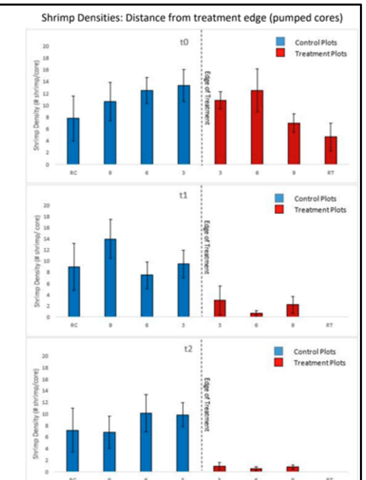


Figure 17. Mean shrimp densities from pumped cores along a distance gradient from treatment edge at times t0, t1, and t2 for transects moving into treated plots. Error bars indicate standard error.

Slide 24

Act 1 Problem 5a: After dry harrowing, do shrimp move into untreated areas?

In these graphs, the dotted line represents the edge of the treatment. The distance from the dotted line represents the distance of a plot from the border. Source: Willapa Bay Mechanical Management of Burrowing Shrimp, WADNR 2018

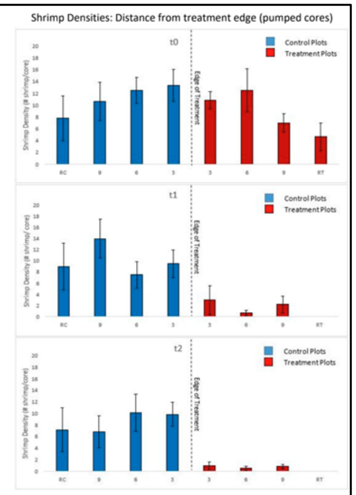


Figure 17. Mean shrimp densities from pumped cores along a distance gradient from treatment edge at times t0, t1, and t2 for transects moving into treated plots. Error bars indicate standard error.

Slide 25

Act 1 Problem 5b: After dry harrowing, do shrimp move into untreated areas?

In these graphs, the dotted line represents the edge of the treatment. The distance from the dotted line represents the distance of a plot from the border. Source: Willapa Bay Mechanical Management of Burrowing Shrimp, WADNR 2018

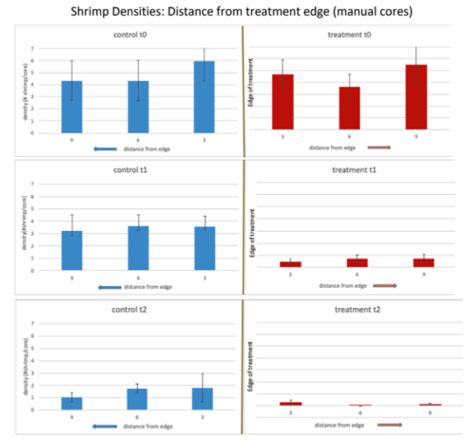


Figure 18. Mean shrimp densities from manual cores along a distance gradient from treatment edge, at times t0, t1 and t2. Error bars indicate standard error.

Slide 26

Act 2 Problem 5: After dry harrowing, do shrimp move into untreated areas?

What else do you need to know to solve your problem?

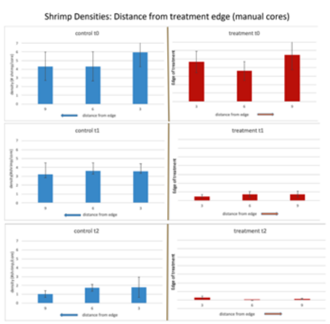


Figure 18. Mean shrimp densities from manual cores along a distance gradient from treatment edge, at times t0, t1 and t2. Error bars indicate standard error.

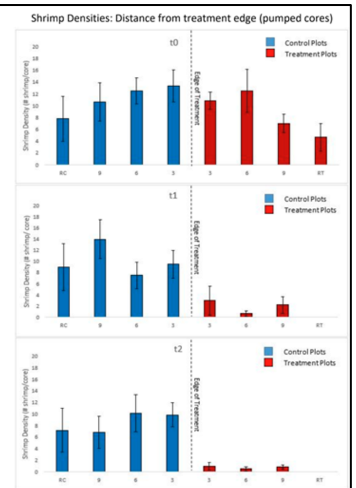


Figure 17. Mean shrimp densities from pumped cores along a distance gradient from treatment edge at times t0, t1, and t2 for transects moving into treated plots. Error bars indicate standard error.

Slide 27

Act 3 Problem 5a: After dry harrowing, do shrimp move into untreated areas?

Answer: It does not appear that the shrimp are moving. In the control plots, population at each location fluctuates up and down. In the experiment plots, population decreases over time. If there was movement from control to experiment plots, you would expect to see the population on the red 3 meter mark increase or at least not decrease over time, but this didn't happen.

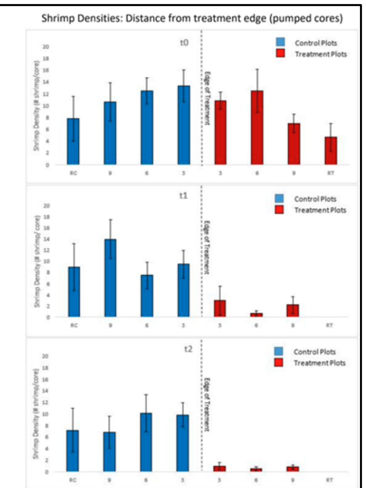


Figure 17. Mean shrimp densities from pumped cores along a distance gradient from treatment edge at times t0, t1, and t2 for transects moving into treated plots. Error bars indicate standard error.

Slide 28

Act 3 Problem 5b: After dry harrowing, do shrimp move into untreated areas?

Answer: It does not appear that the shrimp are moving. In the control plots, population at each location does always decrease over time. In the experiment plots, population decreases more drastically.

If there was movement from control to experiment plots, you would expect to see the population on the red 3 meter mark increase or at least not decrease over time, but this didn't happen.

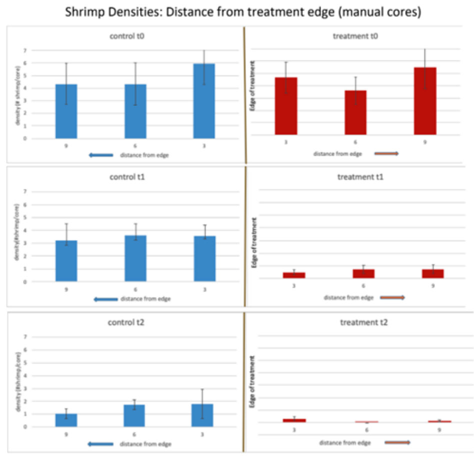


Figure 18. Mean shrimp densities from manual cores along a distance gradient from treatment edge, at times t0, t1 and t2. Error bars indicate standard error.

Slide 29

Problem 6: Notice and Wonder

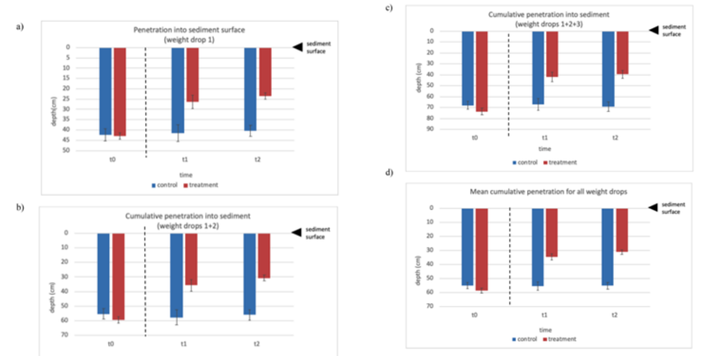


Figure 23. Sediment penetration depth pre- and post- dry harrow treatment measured in DH4-DH6 and control plots after a) first weight drop, b) cumulative penetration after first and second weight drop, c) cumulative depth penetrated after all three weight drops, and, d) mean penetration for all weight drops.

Slide 30

Act 1 Problem 6: Did dry harrowing reduce shrimp enough to make the sand more compacted?

Source:
Willapa Bay Mechanical Management of Burrowing Shrimp, WADNR 2018

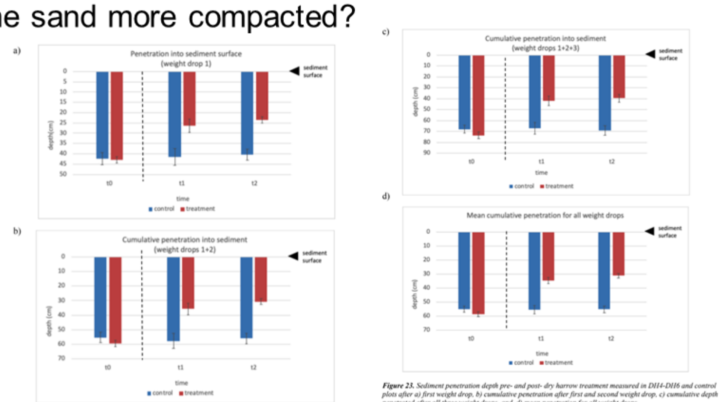


Figure 23. Sediment penetration depth pre- and post- dry harrow treatment measured in DH4-DH6 and control plots after a) first weight drop, b) cumulative penetration after first and second weight drop, c) cumulative depth penetrated after all three weight drops, and, d) mean penetration for all weight drops.

Slide 31

Act 2 Problem 6: Did dry harrowing reduce shrimp enough to make the sand more compacted?

What do you need to know to answer your question?

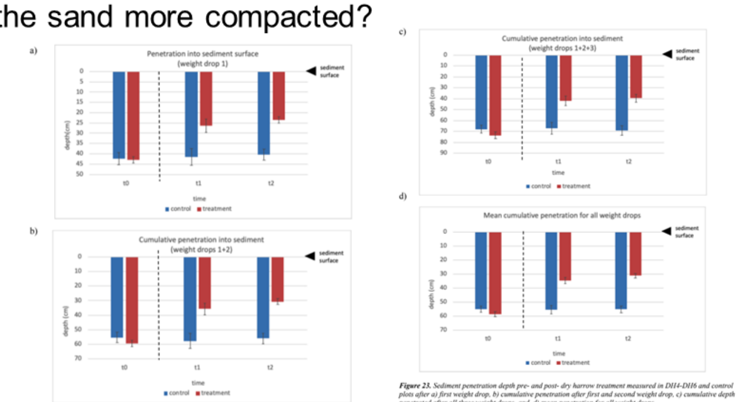


Figure 23. Sediment penetration depth pre- and post- dry harrow treatment measured in DH4-DH6 and control plots after a) first weight drop, b) cumulative penetration after first and second weight drop, c) cumulative depth penetrated after all three weight drops, and, d) mean penetration for all weight drops.

Slide 32

Act 3 Problem 6: Did dry harrowing reduce shrimp enough to make the sand more compacted?

Answer: Yes, it did. There does not appear to be any change in the control plots even though their population went down, too (as we saw on previous problems).

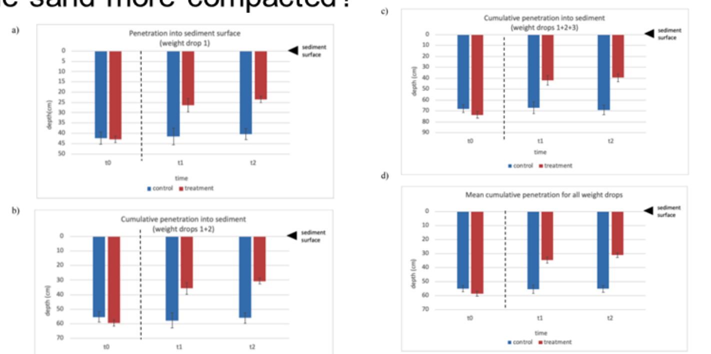
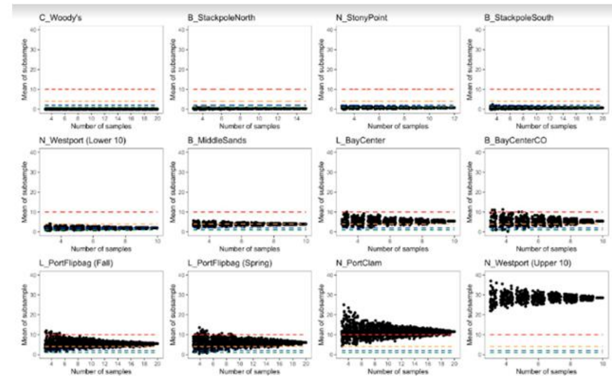


Figure 23. Sediment penetration depth pre- and post- dry harrow treatment measured in DH4-DH6 and control plots after a) first weight drop, b) cumulative penetration after first and second weight drop, c) cumulative depth penetrated after all three weight drops, and, d) mean penetration for all weight drops.

Slide 33

Problem 7: Notice and Wonder



Slide 34

Act 1 Problem 7: What is your recommendation to make the most accurate population estimates? Growers hope for less than two shrimp per sample.

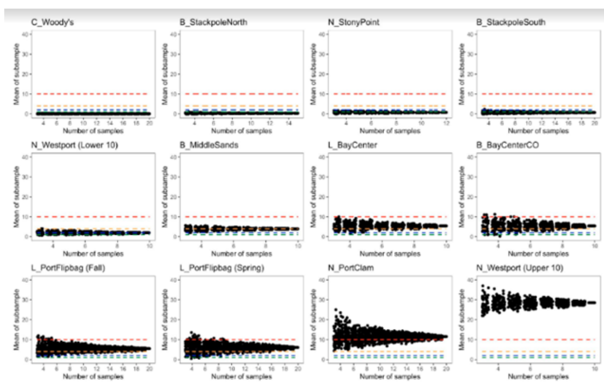
Ghost shrimp populations were measured in both Grays Harbor and Willapa Harbor at different locations.

This figure shows the model output for randomized subsets of mean shrimp density data based on number of samples collected.

Mean number shrimp was calculated from a random subset of actual samples, without replacement.

Dashed lines represent thresholds of shrimp density.

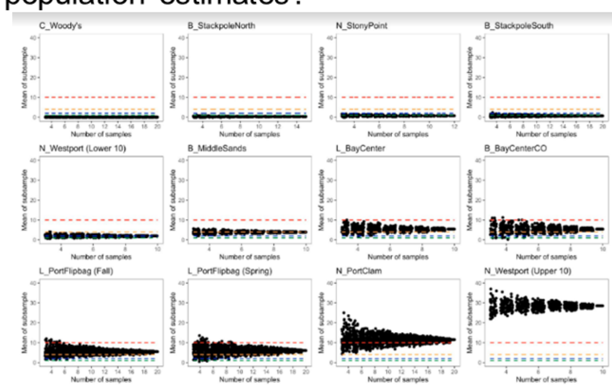
Source: Figure 8, Assessment of burrowing shrimp densities on shellfish aquaculture beds in Grays Harbor and Willapa Bay by hand-coring technique, Subbotin and Ruesink 2021.



Slide 35

Act 2 Problem 7: What is your recommendation to make the most accurate population estimates?

What else do you need to know to solve your problem?



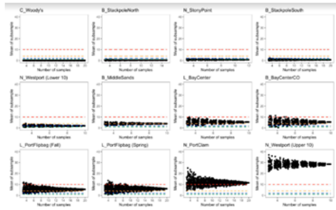
Slide 36

Act 3 Problem 7: What is your recommendation to make the most accurate population estimates?

Answer: the more samples you can take, the more accurate your population estimate will be.

For sites in the top row that had low populations and low variability, four samples will be enough to know if the population is under 2 shrimp per sample.

When there is a population gradient, meaning there is a lot of variability in the population, you need to take 10 to 20 samples in order to get an accurate estimate. So if your first 10 samples have a lot of variability, take 10 more.



Slide 37

Information: What do burrows on the sand look like?

Here are examples of how the surfaces of different sites can appear. The holes usually indicate the burrow of some type of animal, including the ghost shrimp.

Source: Assessment of burrowing shrimp densities on shellfish aquaculture beds in Grays Harbor and Willapa Bay by hand-coring technique (Subbotin and Ruesink 2021)

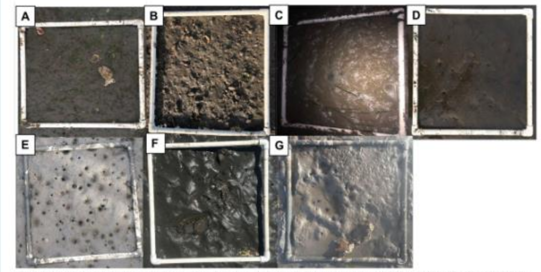


Figure 3. *Pictures of samples taken from a number of study sites.* ***A)*** *Stackpole S,* ***B)*** *Woody's,* ***C)*** *Port - Flipbag (Fall) ,* ***D)*** *Westport,* ***E)*** *Bay Center,* ***F)*** *Bay Center CO,* ***G)*** *Middle Sands*

Slide 38

Information: What is dry harrowing?

Dry Harrow Treatment: Dry harrowing involved towing a robust steel roller behind an amphibious tracked vehicle called the "Marsh Master-2LX" (Figure 2). The roller is a product from Coast Machinery LLC., weighs 700 pounds empty, and is designed to cut an 8-foot wide swath through marsh and wetland cat-tail (Coast Machinery LLC. 2018). It has a series of flat plates welded to it, which penetrate into the sediment approximately 30 cm. The implement can be either hooked up to a 4 point hydraulic hitch, or towed with load bearing rope. It both crushes and forces shrimp out of their burrows where they can be consumed by birds.

Source: Willapa Bay Mechanical Management of Burrowing Shrimp Supplement July 2018 WA Dept of Natural Resources.

Figure 2. WDNR Marshmaster-2XL *towing the roller – chopper "dry harrow" implement at Grassy Island, treating a dry harrow plot.*

Slide 39

Information: What is a pumped core?

To assess shrimp density and biomass at each plot, the entire contents of a 1/8 meter² (m²) surface area core was liquified. Shrimp are buoyant and float to the surface of the core, where they are scooped up, placed in site-specific labelled bags then frozen for later lab processing.

Source: Willapa Bay Mechanical Management of Burrowing Shrimp Supplement July 2018 WA Dept of Natural Resources.

Figures 4 and 5. *Large core hydraulically pumped out and used for assessing shrimp density. The core is one meter deep with a surface area of 1/8 m².*

Slide 40

Information: What is a manual core?

Clam guns are used to excavate sediment cores of one meter in depth and approximately .078 m^2 in surface area (Figure 6). Once the sand is excavated, then organisms are counted.

Source: Willapa Bay Mechanical Management of Burrowing Shrimp Supplement July 2018 WA Dept of Natural Resources.

Figure 6. Manual coring method

Slide 41

Information: How did they set up the core samples?

The axes are measured in meters. For a manual core, the entire m^2 was dug up and shrimp were counted. For the pumped core, a ⅛ m2 core was taken and its contents multiplied by 8 to determine the population in that m^2 section.

Source: Willapa Bay Mechanical Management of Burrowing Shrimp Supplement July 2018 WA Dept of Natural Resources.

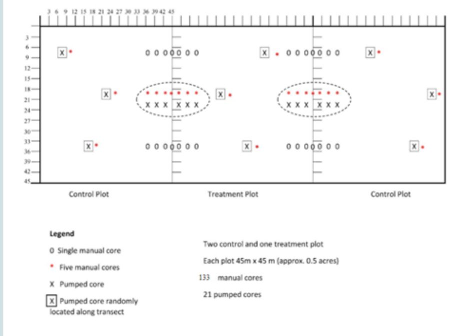


Figure 3. Schematic of sampling locations for one set of dry harrow plot and subsequent controls. Gradient transects are encircled by dotted lines.

Slide 42

Information: How did they determine sand compactness?

They used this tool. The base plate started on the surface of the sand and got driven into the sand by dropping the weight. The softer the sand, the farther the base plate would drive into the sand.

Source: Willapa Bay Mechanical Management of Burrowing Shrimp Supplement July 2018 WA Dept of Natural Resources.

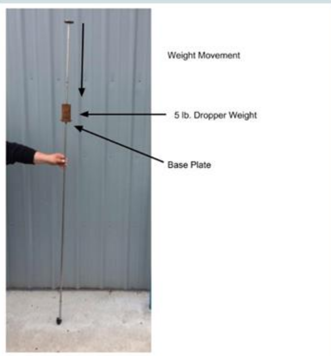


Figure 7. Penetrometer used to measure sediment compaction before and after treatment

Slide 43

Information: Where was the study for problem 7?

These areas were studied.

Source: Figure 1, Assessment of burrowing shrimp densities on shellfish aquaculture beds in Grays Harbor and Willapa Bay by hand-coring technique, Subbotin and Ruesink 2021.

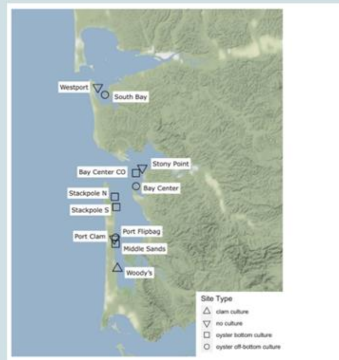


Figure 1. Map of study sites in Willapa Bay and Grays Harbor. Shape indicates culture type.

Slide 44

Following this page are printable student materials. Print the information cards you need for the problems you choose.

Recording Sheet

Name: ______________________________________ Group: ____________________ Date: _______________

Notice	Wonder

1. Group Question:

2. Prediction:

3. Materials List:

4. Solution Thinking:

5. Final Answer:

6. Self-Reflection

Sentence Stems for working in your groups

I saw ________, so I connected that to ________ .

We know ________ because ________ .

Since ________ , then we can calculate ________ .

I think ________ because ________ .

I learned that ________ .

I agree because ________ .

I respectfully disagree because ________ .

Can you explain ________ ?

I can see connections between ________ and ________ because _______ .

So, what I think ________ is saying is that ________ . Is that correct?

Introduction to the Problem

The context: Aquaculture is the rearing of aquatic animals or the cultivation of aquatic plants for food. The company Pacific Seafood, has tidelands available in Grays Harbor and in Willapa Bay for the aquaculture of oysters. Because of how laws have changed over time, the lands the company has available are all they can access--they cannot purchase new or move locations. They can't get more land; they can only use what they have. They want to make the most efficient and profitable use of the land, while maintaining their Best Aquaculture Practices certification.

When growing oysters, the company will "plant oyster seed" meaning they deposit tiny baby oysters in the tide lands and then wait for them to grow to harvestable size. Olympia Oyster (Ostreola conchaphila) take about four years to reach their maximum size of 3 inches, while Pacific Oyster (Crassostrea gigas) can reach 4-6 inches in two to four years of growing.

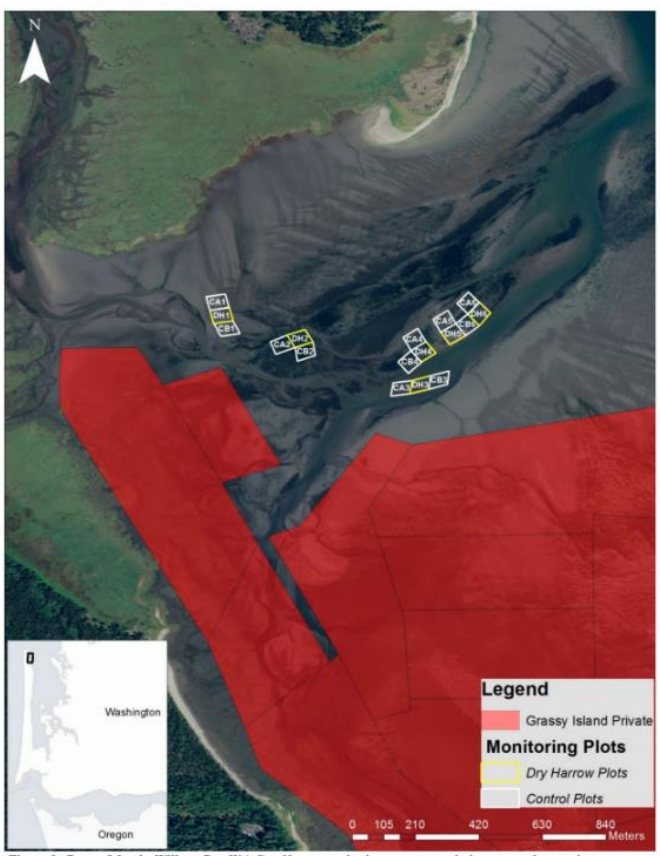


Figure 1. Grassy Island - Willapa Bay WA. *Dry Harrow and subsequent control plots in supplemental monitoring study. The dashed line indicates plots DH4 through DH6 - established for supplemental monitoring.*

The problem: Ghost shrimp are a native species that lives in this environment. The ghost shrimp feed by "bioturbation", meaning they shuffle up the sand in search of food. Their search for food causes any baby oysters nearby to be covered by sand and then suffocated. Instead of hard packed sand, which is better for oysters, the bioturbation causes the sand to be very soft, with the texture of quicksand.

A study was conducted to determine the best way to gather information about shrimp abundance on shellfish beds as well as on the effects of a shrimp control treatment called "dry harrowing." This map shows the locations that were studied. Control plots did not have any treatment and were located directly next to the experimental dry harrow plots.

Information Card for Problem 1

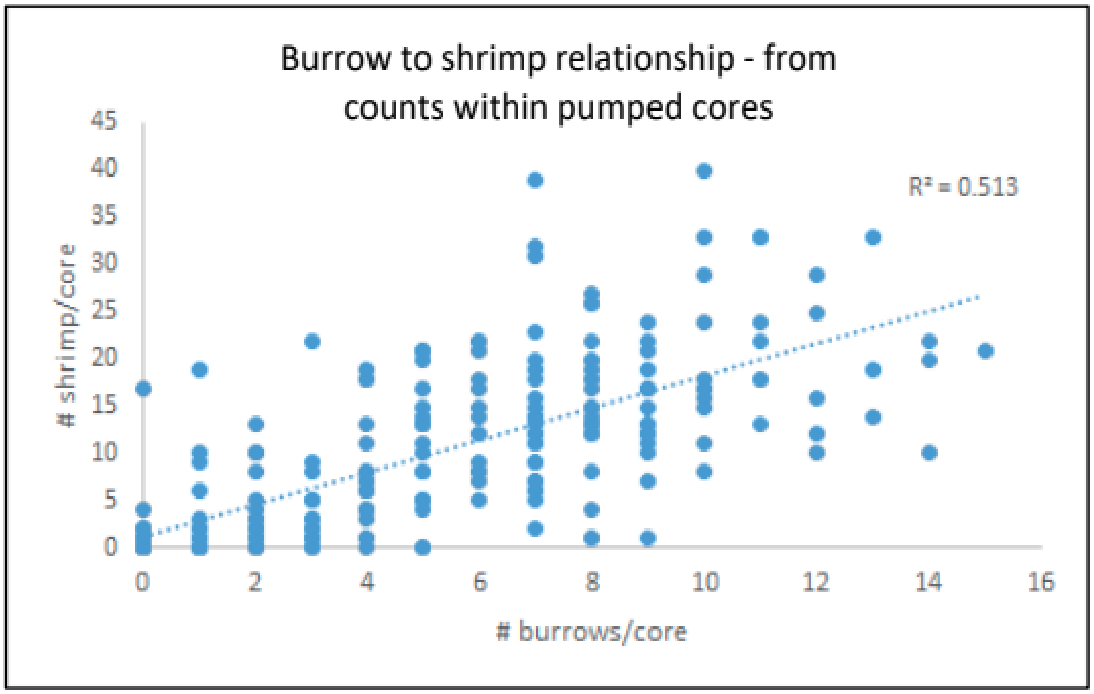


Figure 19. *Burrow counts compared with shrimp density collected from within pumped cores ($p = 0.001$, $n=243$). Pumped cores were 20 cm diameter or 0.125 m², (1/8m²) in surface area.*

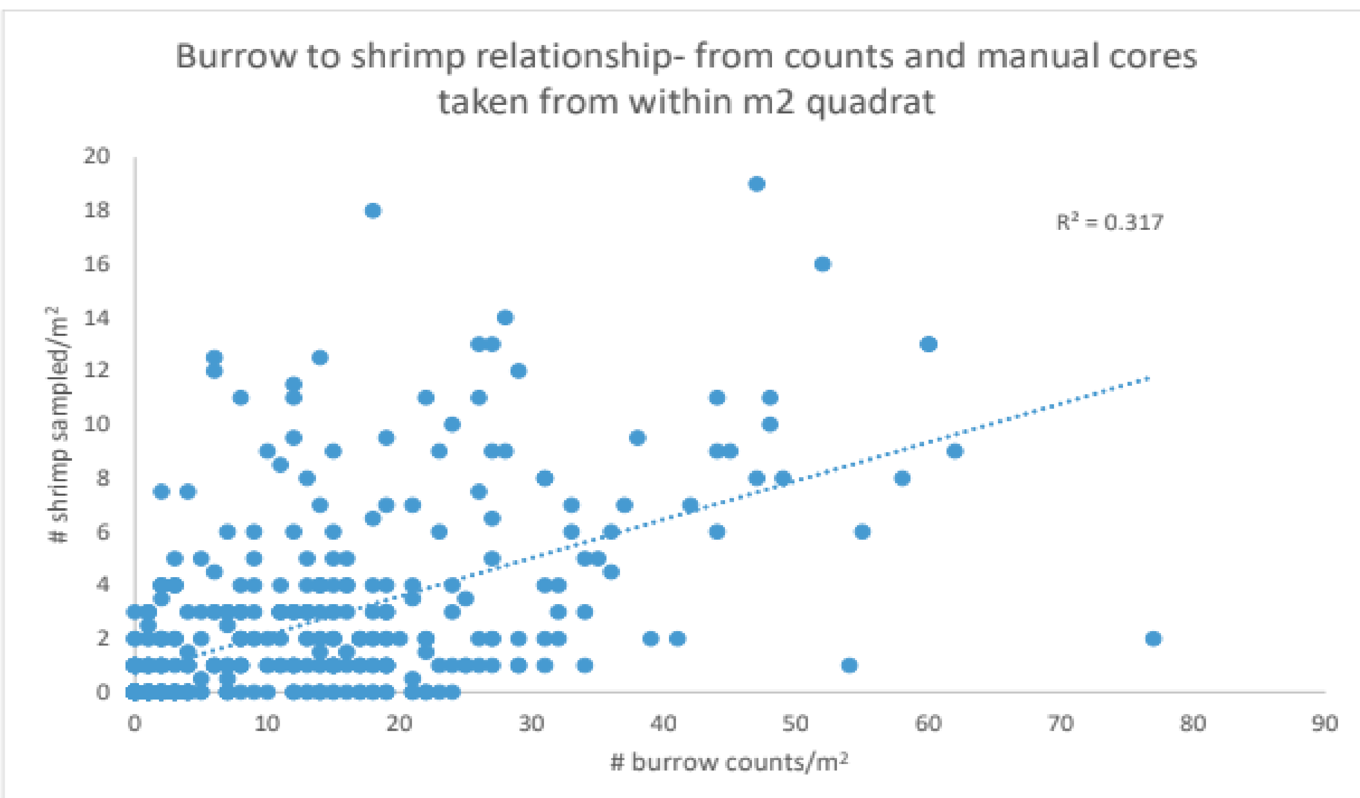


Figure 20. *Burrow counts compared with shrimp density collected from within a square meter quadrat ($p = 0.001$, $n= 415$).*

Information Card for Problem 2

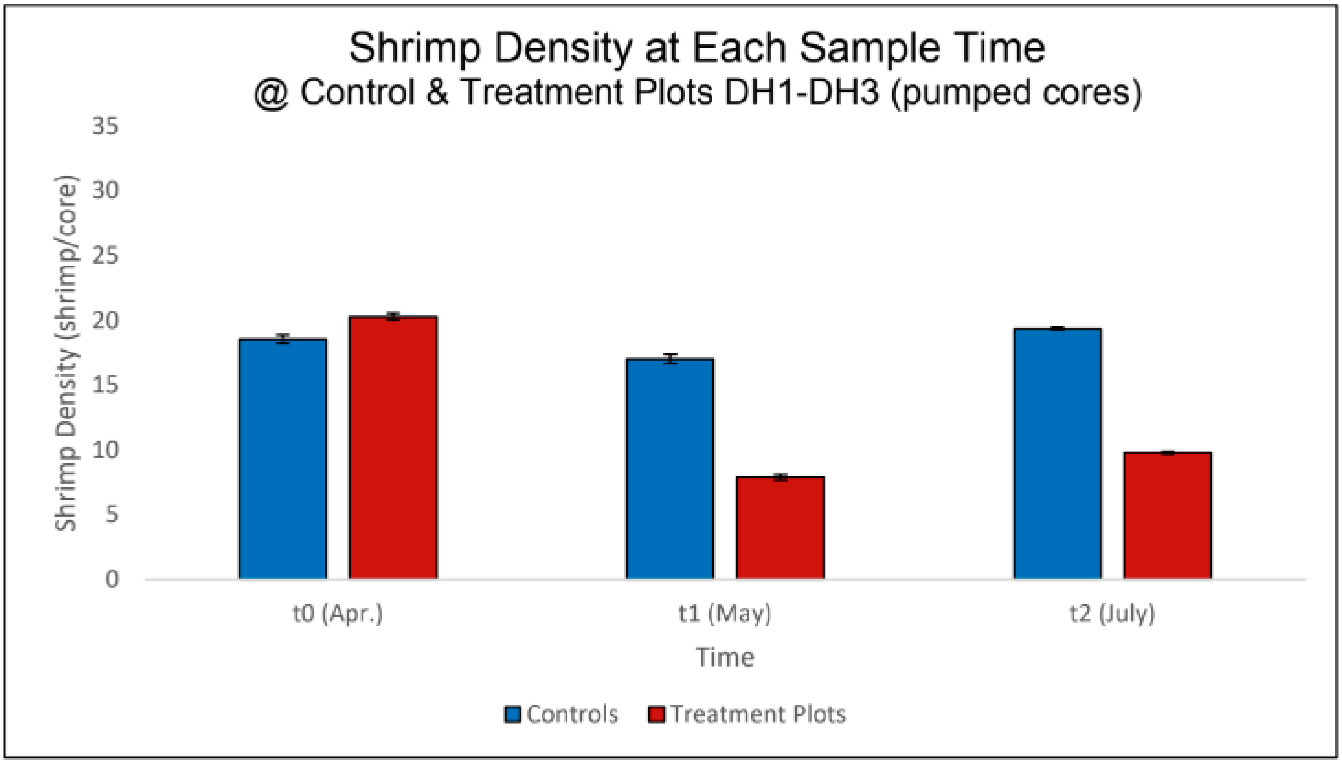


Figure 25. *Mean burrowing shrimp density for control and treatment DH1-DH3 plots from POC experiment. Plots dry harrowed with two passes of the roller-chopper, and revisited for monitoring in May and July.*

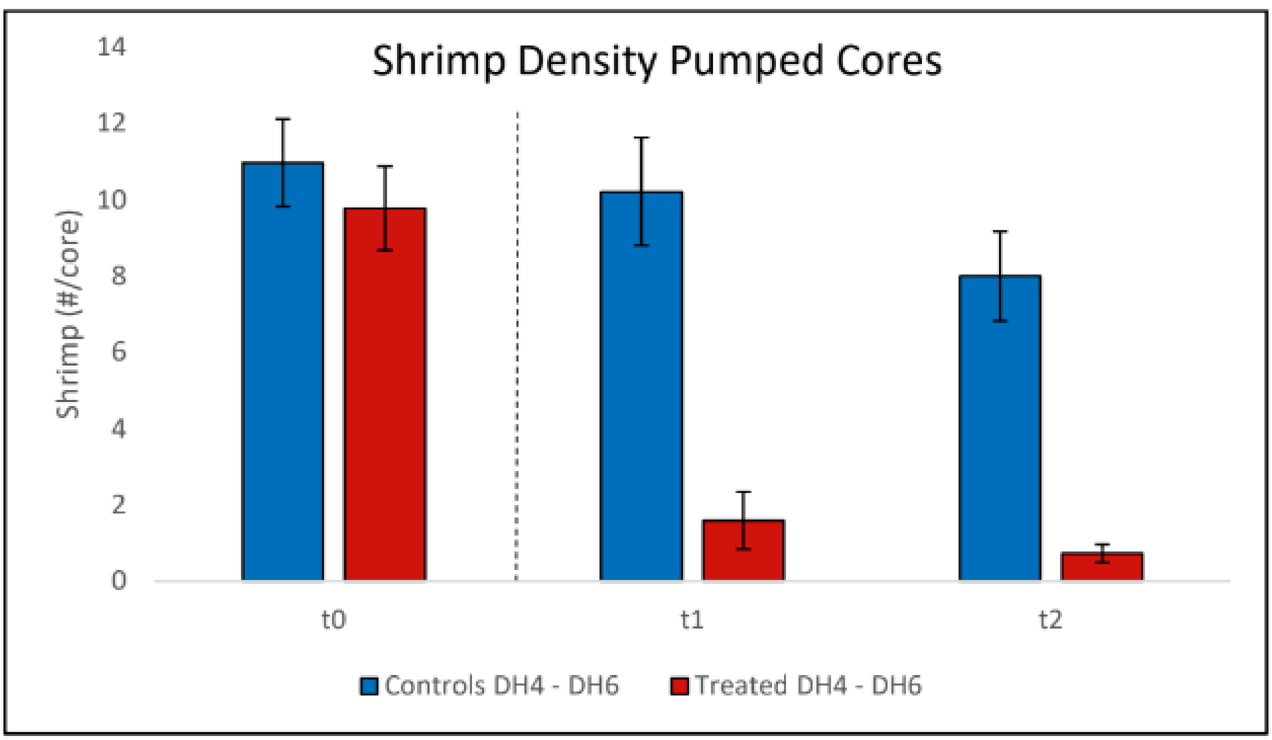


Figure 8. *Mean shrimp density collected per pumped core at Control and Treated plots at t0, t1, and t2 (shrimp/0.125m²). Dotted line indicates timing of treatment.*

Information Card for Problem 3

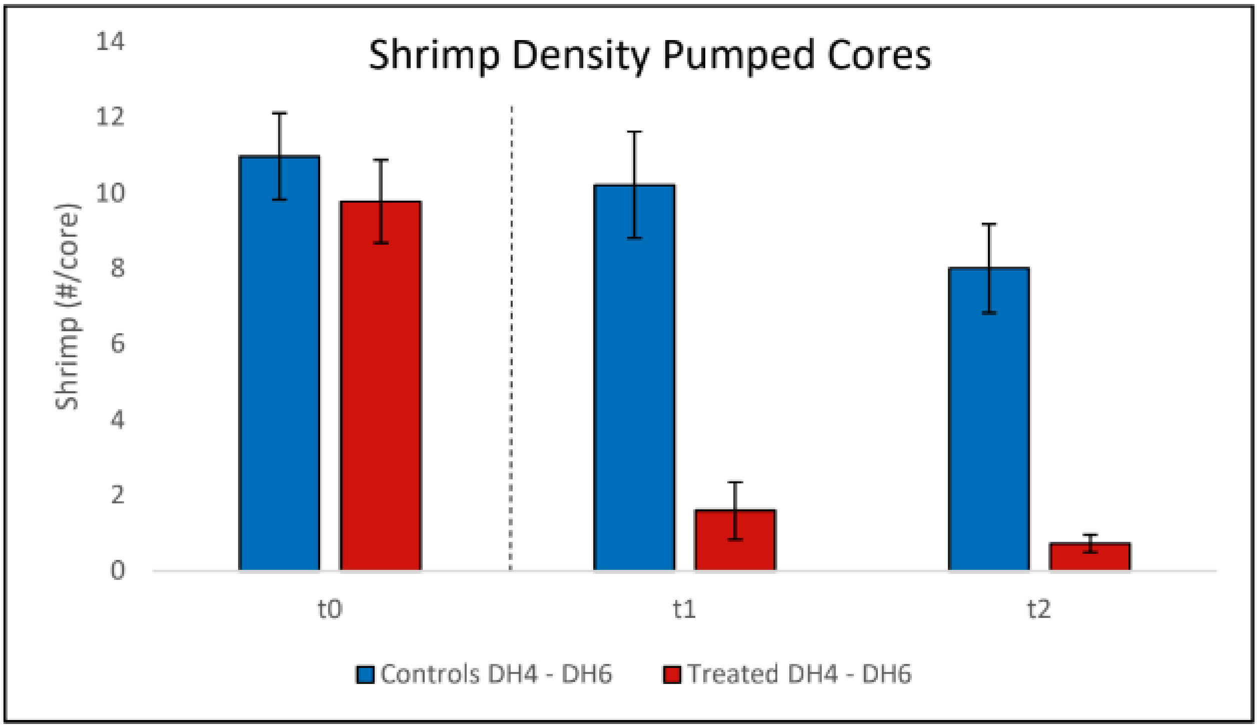


Figure 8. *Mean shrimp density collected per pumped core at Control and Treated plots at t0, t1, and t2 (shrimp/0.125m²). Dotted line indicates timing of treatment.*

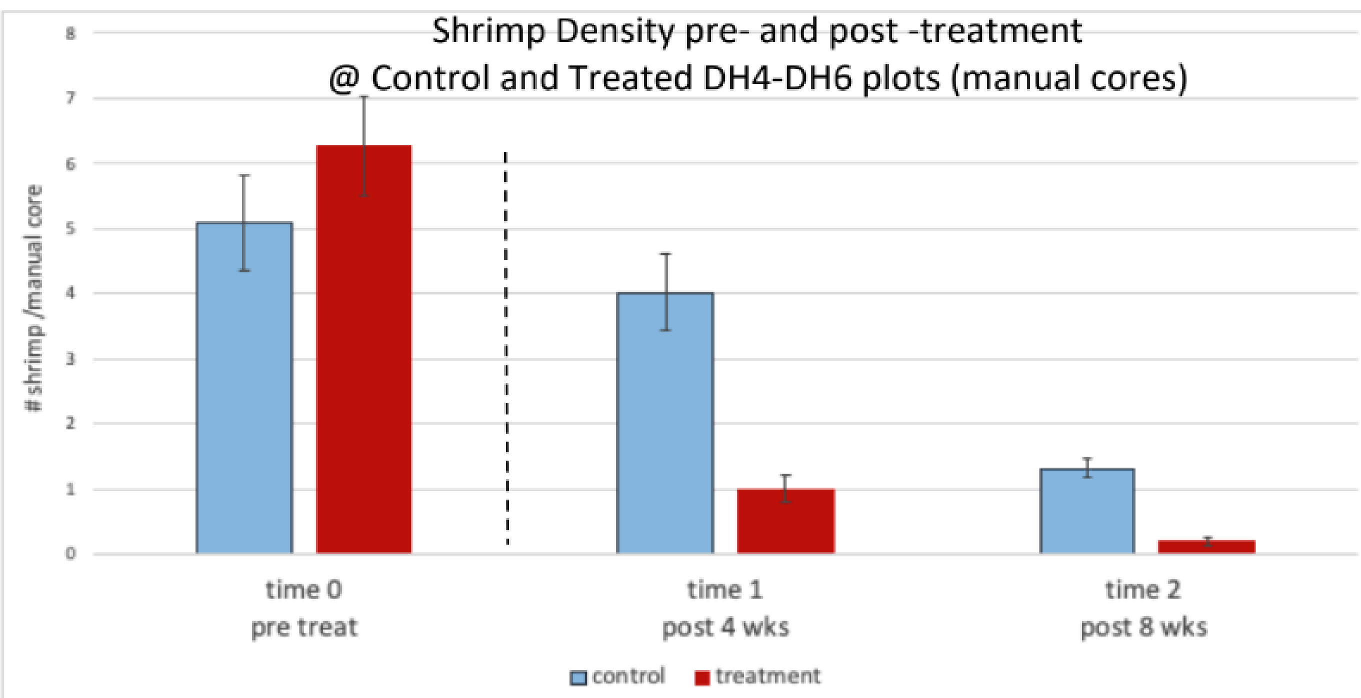


Figure 12. *Mean shrimp density collected by manual core in Control and Treated plots at t0, t1, and t2. Dashed line indicates relative timing of treatment.*

Information Card for Problem 4

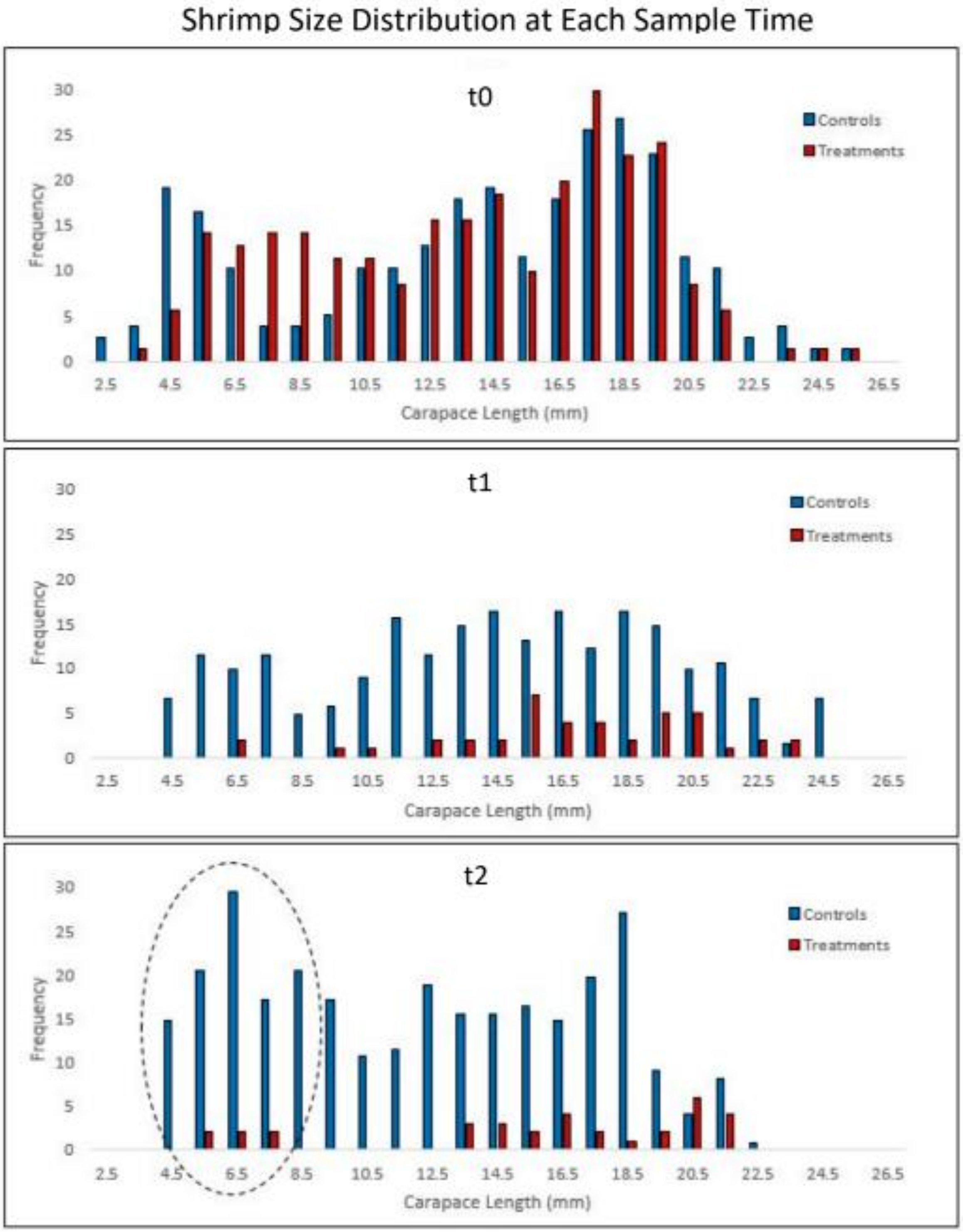


Figure 14. *Carapace lengths (CL) for treated and control plots - shrimp at t0, t1, and t2 collected from pumped density cores for plots DH4, DH5 and DH6. An increase in the magnitude of the extra small class can be seen within circled region at t2.*

Information Card for Problem 5 (page 1)

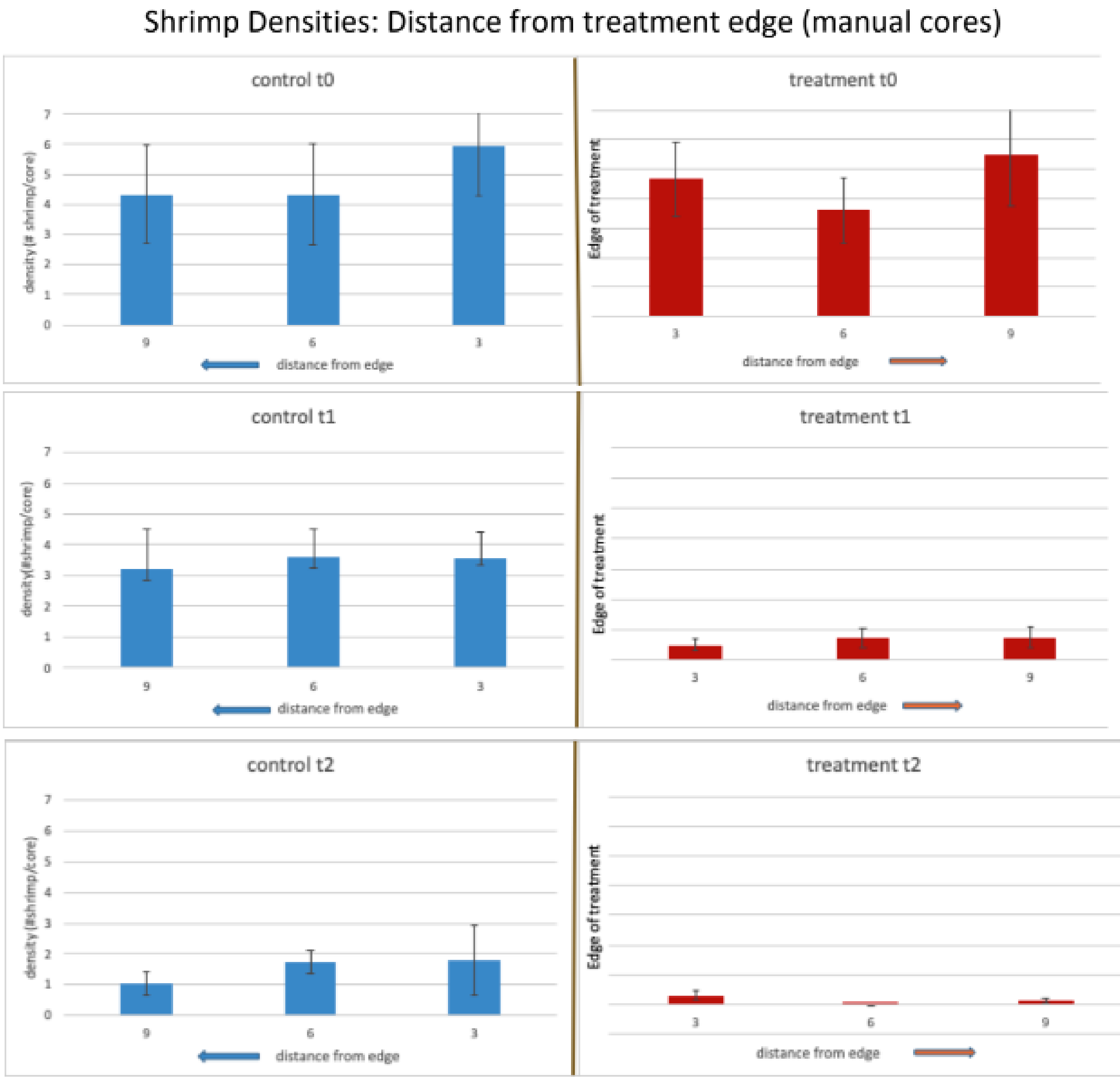


Figure 18. Mean shrimp densities from manual cores along a distance gradient from treatment edge, at times t0, t1 and t2. Error bars indicate standard error.

Information Card for Problem 5 (page 2)

Shrimp Densities: Distance from treatment edge (pumped cores)

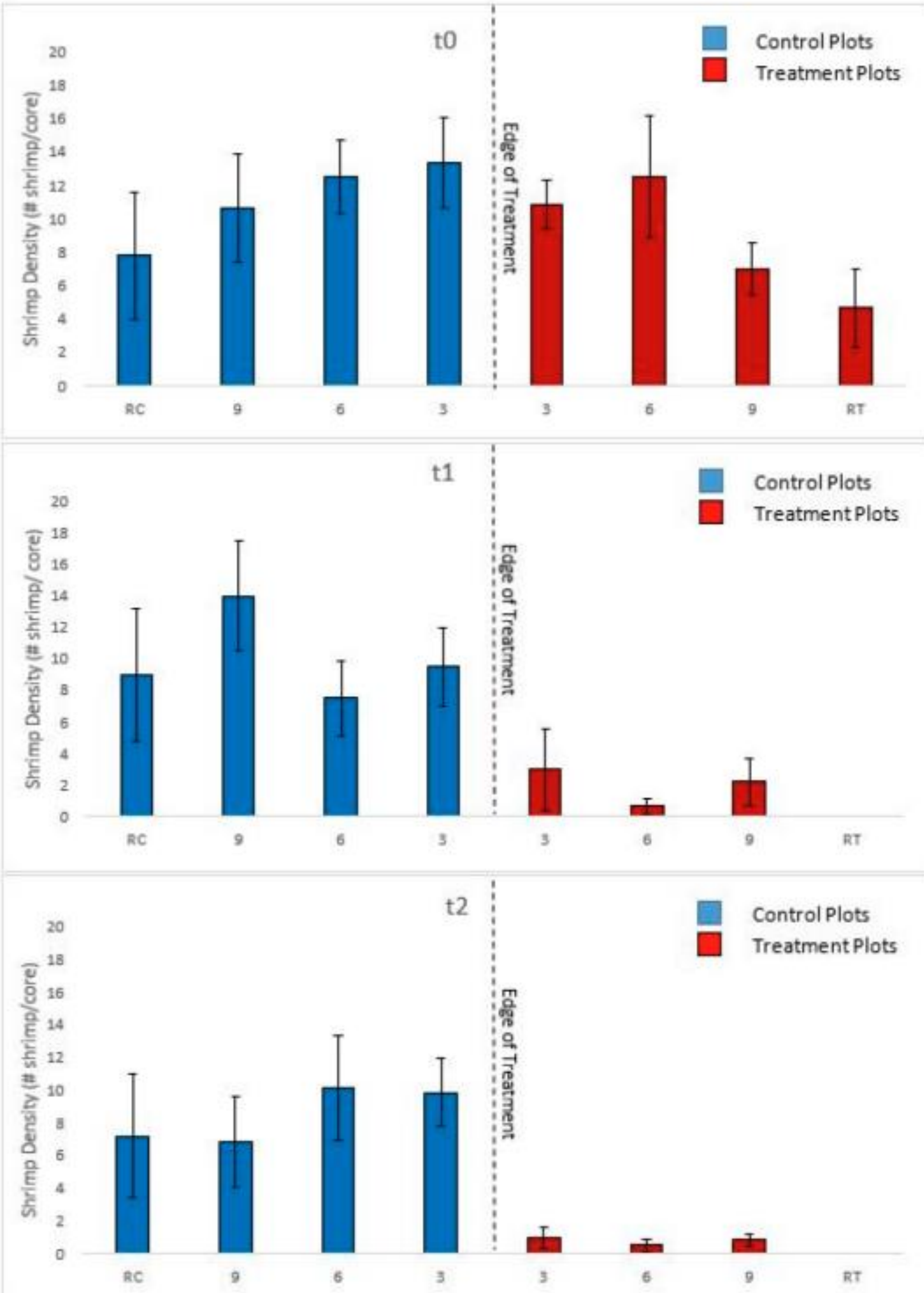


Figure 17. *Mean shrimp densities from pumped cores along a distance gradient from treatment edge at times t0, t1, and t2 for transects moving into treated plots. Error bars indicate standard error.*

Information Card for Problem 6

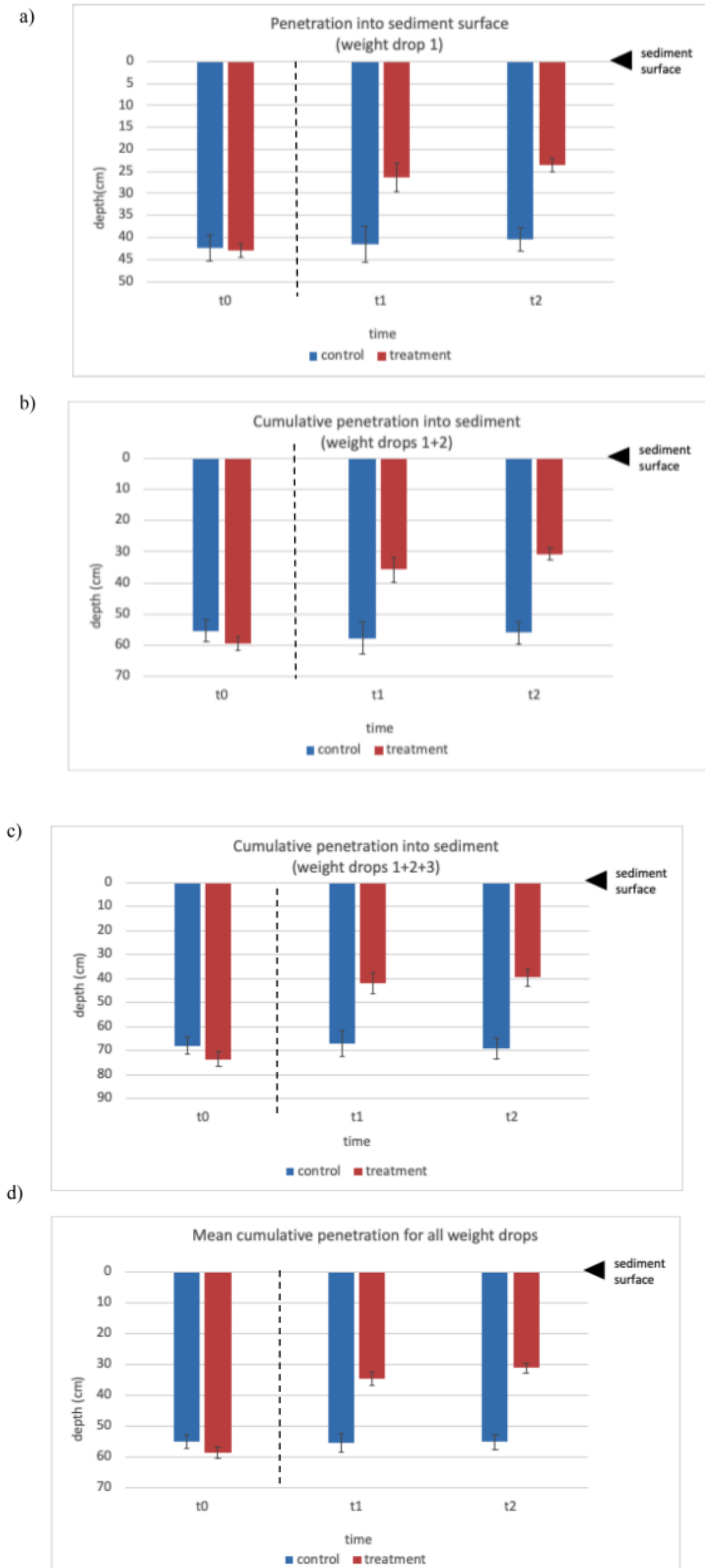


Figure 23. *Sediment penetration depth pre- and post- dry harrow treatment measured in DH4-DH6 and control plots after a) first weight drop, b) cumulative penetration after first and second weight drop, c) cumulative depth penetrated after all three weight drops, and, d) mean penetration for all weight drops.*

Information Card for Problem 7