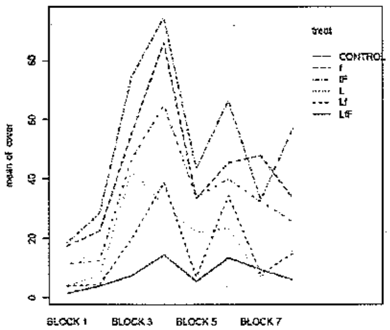
15/15

Introduction

The goal of our experiment was to study the effect of seaweed-grazing animals on regeneration rates of seaweed in the intertidal zone. We tried to regrow seaweed on plots of rock which were exposed to a combination of limpets, small fishes, and large fishes. In total, we had six different treatment groups: all 3, all but limpets, all but large fishes, only small fishes, only limpets, and none of them (we wanted to test for only large fishes but we could not let large fishes in without also letting small fishes in). We also divided the intertidal zone into eight blocks because we suspected the strength of tide and surf would affect seaweed growth. Each block was then divided into twelve 100cm-by-100cm areas, and each treatment was randomly assigned to two of these areas. After four weeks, we measured the percentage of the area that was covered by seaweeds.

Great!

Data Analysis



On the left is the graph of mean percentage area that was covered for each block and treatment combination. Each line represents a different treatment. We would expect the lines to be parallel if the area and treatment do not interact, meaning the presence of a particular block affects the effect of a treatment ~~group on~~ the mean of covered area. We see some lines intersecting so we suspect an interaction between treatments and blocks. We also observe that seaweed growth were better when the limpets were not present (lines CONTROL, f, and fF).

not a good indicator of interaction especially with each point representing only 2 measurements.

probably not worth mentioning to the boss, given that it was not significant.

We conducted the analysis of variance test for two-way classifications. When we first checked the residual plot of the fitted model, we observed non-randomness, which suggests non-linearity and non-constant variance, two of the assumptions we need for the model. However, when we transformed the percentage mean to log(percent/(100-percent)), the problem was fixed.

We tested the null hypothesis that there is no interaction between treatment and block, and we found a statistically non-significant result (p-value 0.121). We concluded that there is not enough evidence for an interaction between treatment and block, so the additive model (with no interaction) is more appropriate.

← no block contrasts were done

To test how individual ~~blocks and~~ treatments affect the mean percentage area of coverage, we conducted contrast tests. We found statistically significant results for all of the five comparisons we did: control vs. others, large and small fishes vs. all three treatments, small fishes vs. small and large fishes, all three treatments vs. limpets, and limpets vs. all three treatments. The 95% confidence intervals for the differences between the two groups in these five comparisons did not include 0 (which implies no difference). It showed that the existence of limpets reduced the coverage area significantly, more than the small and large fishes did. The most significant was the comparison between the control group and all others. It showed that the ratio of covered area to non-covered area is 3.9 to 7.6 times bigger for control than the average of all other groups.

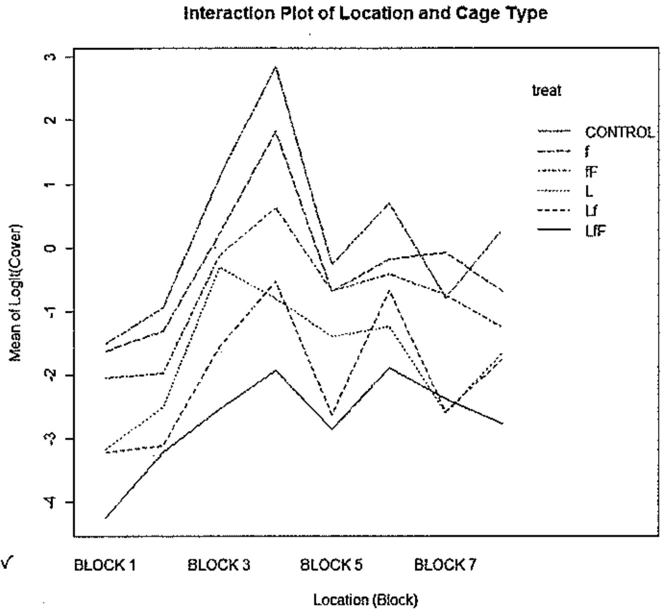
As a statistician, don't include subject matter explanations on a report to a subject matter expert.

Good Job! 5/15

Homework #4
Writing Exercise #1

This study was designed to observe seaweed regrowth (% coverage) on rocks that were scraped clean of seaweed at 8 different locations on the sea floor. These 8 locations were treated as blocks because there were differing important, non-quantifiable conditions at each location. Different kinds of cages and barriers were used as the treatment to keep out different forms of sea life – limpets (a ~~kind of~~ snail), small fish, and large fish. Each treatment was used twice at each location, and treatment is considered as a single factor with 6 levels (for technical reasons).

After analyzing the initial round of plots to visualize the data, we transformed the regrowth percentage using a logit function (log(percent/(100-percent))) and re-created the plots; the interaction plot is shown below.



Better to avoid this term when writing for the subject matter expert.

Because the lines in this plot are not parallel, we have evidence that there may be an interaction between treatment (cage type) and block (location). However, we tested this theory using regression and found that the interaction is not statistically significant. In other words, we retain the null hypothesis that an additive model using treatment and block is sufficient.

The plot also indicates that the limpets, small fish, and large fish may inhibit algae regrowth because cages that do not allow any or all of those creatures showed higher logit percentages of regrowth (note the difference in regrowth between the control line, or no creatures (top), and the bottom line, all creatures). We tested these differences using fit contrasts; the most interesting results are as follows (presented as 95% confidence intervals): the covered to not covered ratio is 3.9 to 7.6 times bigger for the control vs. the average of the other groups; the ratio is 3.7 to 6.4 times bigger for allowing both types of fish vs. allowing both fish and limpets. These results indicate that we have evidence that small fish, large fish and limpets all inhibit regrowth, with limpets being more destructive than the fish.

[redacted] TA #1

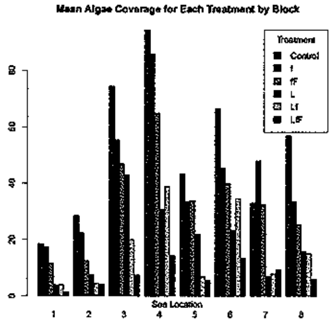
Homework 4, Question 2

An 8 × 6 randomized two-way ANOVA was performed on a logit-transformed value of the percentage of algae coverage on sea rocks for various kinds of barriers and cages that keep out different sorts of sea life. The barriers/cages include a control (C), consisting of no barrier, and combinations of barriers to keep out small fish (f), large fish (F), and limpets (L). Combinations of cages are given by their associated letters, for example, *Lf* denotes a barrier for limpets and small fish. Two samples of each barrier type, C, F, f, Ff, Lf, LFf, were observed for 8 different sea locations, for a balanced design with a total of 96 samples. The non-transformed percentage of algae coverage showed severe heterogeneity of variance and nonlinearity of barriers/cages and sea locations with respect to algae coverage. The logit-transformation, $\log\left\{\frac{\text{Percent Coverage}}{100-\text{Percent Coverage}}\right\}$, seemed to correct for this. The figure below shows means for the un-transformed algae coverage for each treatment and location.

There was statistically significant differences in the cages/barriers averaging over sea locations ($F_{5,83} = 96.99, p < .001$), ranging from the highest amount for *Control* with a mean algae coverage of 54.5% (95% CI=47.1 to 67.1) and the lowest algae coverage for *LfF* with mean 6.2% (95% CI=4.6 to 8.1). As expected, there was a signifcant difference in the algae coverage in sea floor locations, averaging over the cages/barriers ($F_{7,83} = 30.368, p < .001$), ranging from the lowest mean coverage in *Location 1* with 6.7% (95% CI=4.8% to 9.2%) to the highest in *Location 4* with mean 58.5% (95% CI=50.0 to 66.6). We saw no significant interaction between sea location and cages.

Planned comparisons among means were tested using a Bonferroni corrected $\alpha = .01$ (we note that although these are planned contrasts, they are not orthogonal). A summary of comparisons can be seen below, where the estimates are the odds ratios between the groups (odds defined as $\frac{\text{Percent Coverage}}{100-\text{Percent Coverage}}$). For example, the odds of algae coverage for the control group is almost five and half times greater than the average odds of the other treatments.

As expected, the odds of algae coverage for *Control* rocks was significant greater than the mean odds coverage of rocks with barriers. We also note that there is a minimal difference between the barriers for small (f) and big fish (F). Most interestingly, the addition of a limpet barrier (L) to a fish barrier showed a highly significant reduction in odds of algae coverage as compared to the treatments without the limpet barrier.



Comparison	Odds Ratio Estimate	(95% CI)	p-value
Control vs. Others	5.450	(3.933, 7.553)	< .001
Ff vs. FfL	4.852	(3.697, 6.368)	< .001
f vs. fF	1.662	(1.091, 2.532)	0.019
L vs. LFf	1.920	(1.334, 2.766)	< .001
Lf vs. LfF	2.055	(1.349, 3.131)	0.001

TA #2

Introduction

This study seeks to examine the effect of three different types of seaweed-grazing animals (limpets (L), small fish (f), and large fish(F)) on the regeneration rates (RR) of seaweed in the intertidal zone. Researchers scraped 100cm square rock plots free of seaweed, and placed 12 plots at each of 8 different locations.

Each plot was covered by a cage designed to allow access only to certain combinations of the seaweed-grazing animals. The six cage "treatments" were:

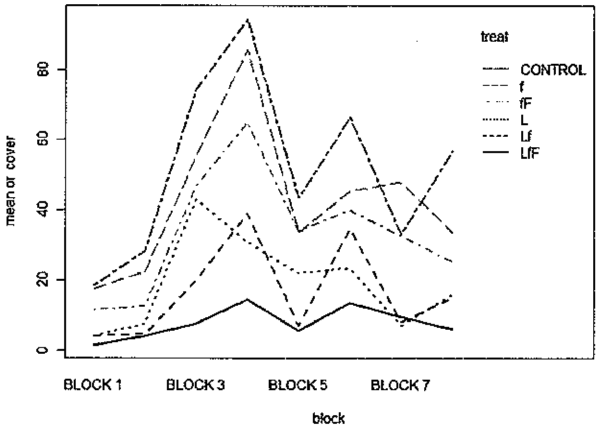
LfF: All three grazers were allowed access
fF: Both types of fish were allowed access, but limpets were excluded
Lf: Large fish were excluded
f: Limpets and large fish were excluded
L: Small fish and large fish were excluded
C: Control: limpets, small fish, and large fish were all excluded

These six treatment levels were each randomly assigned to two of the 12 plots at each of the 8 locations. After four weeks , researchers measured regeneration rates by placing a metal sheeting with 100 holes in it over each rock, and counting the number of holes directly over regenerating seaweed.

The study sought to address the following questions:
Which animal consumes the most seaweed? Do the grazing effects differ by location?

Results:

The plot on the right displays average regeneration rates (y-axis) versus location (x-axis) and treatment types. The blue lines correspond to treatments that allow limpets in, orange lines to treatments that only allow fish, and the black line to our control, where all grazers were excluded. We notice that at all 8 locations, treatments with limpets have the lowest regeneration rates. At every location, fish-only treatments had higher regeneration rates than treatments with limpets, and the control treatment had the highest rates at all but one location.



This data is best modeled by a two-way ANOVA regression model that estimates the log(RR / (100 – RR)) as a function of treatment and location. We chose to estimate log(RR / (100 – RR)) instead of simply estimating RR because regression assumptions are violated when estimating RR directly.

With this model, we did not find an interaction term between treatment and location to be statistically significant. This means that while regeneration rates differed significantly by location, and rates differed significantly by treatment, the amount regeneration rates differed by treatment did not vary by location.

The locations with the highest regeneration rates were locations 3 and 4. These correspond to plots placed at midtide. The lowest regeneration rates were found just below high tide level. Locations that were protected all had higher regeneration rates than the corresponding exposed locations.

The animals with the largest impact on grazing were the limpets. The average regeneration rate at sites with limpets was only 14.4%, versus an overall average of 28.6%. When comparing treatments LfF to fF, we find that the ratio of holes covering regenerating seaweed to holes not covering regenerating seaweed was between 3.7 to 6.4 times *lower* when limpets are present.