

Statistical Ecology  
Stat 555

Power Analysis

**Purpose:** Does size of the shell of the rock whelk *Nucella emarginata* vary on vertical vs. horizontal surfaces in the intertidal zone?

**Data:** n=30 shells were measured on horizontal and vertical surfaces in each of two locations (randomized blocks).

```
MTB > ANOVA 'Size' = Orient Block ;
SUBC> Random 'Block';
SUBC> Means Orient.
```

$H_0: \mu_V = \mu_H$   
 $H_A: \mu_V \neq \mu_H$

**ANOVA: Size versus Orient, Block**

Factor	Type	Levels	Values
Orient	fixed	2	1, 2
Block	random	2	1, 2

Analysis of Variance for Size

Source	DF	SS	MS	F	P
Orient	1	10.21	10.21	0.68	0.410
Block	1	18.41	18.41	1.23	0.269
Error	117	1746.31	14.93		
Total	119	1774.92			

Cannot reject  $H_0$

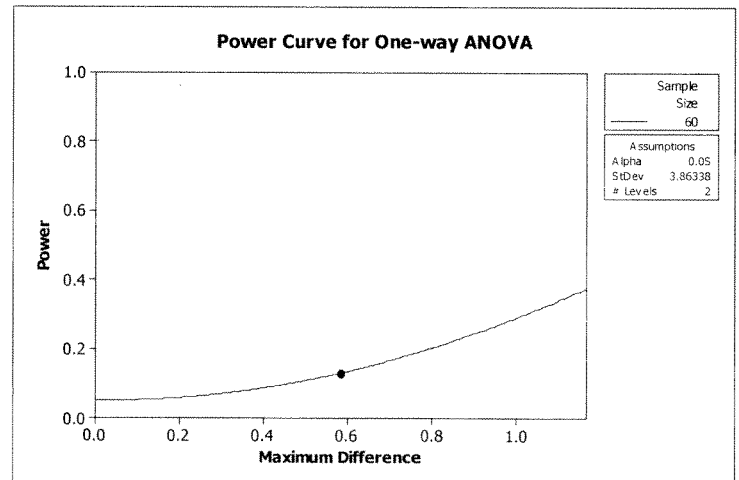
What was power of test?

S = 3.86338 R-Sq = 1.61% R-Sq(adj) = 0.00%

Means	N	Size
Orient		
1	60	16.933
2	60	17.517

Effect Size =  
 $\bar{X}_V - \bar{X}_H = 0.584 \text{ mm}$

```
MTB > Power;
SUBC> OneWay 2;
SUBC> Sample 60;
SUBC> MaxDifference .584;
SUBC> Sigma 3.86338;
SUBC> GPCurve.
```



**Power and Sample Size**

One-way ANOVA

Alpha = 0.05 Assumed standard deviation = 3.86338 Number of Levels = 2

SS Means	Sample Size	Power	Maximum Difference
0.170528	60	0.130115	0.584

The sample size is for each level.

```
MTB > Power;
```

$\beta = 0.87$

Pooled S

Always leave one field blank (Power)

n blank

```
SUBC> OneWay 2;
SUBC> MaxDifference .584;
SUBC> Power .9;
SUBC> Sigma 3.86338;
SUBC> GPCurve.
```

What was sample size needed to detect obs. mean difference?

**Power and Sample Size**

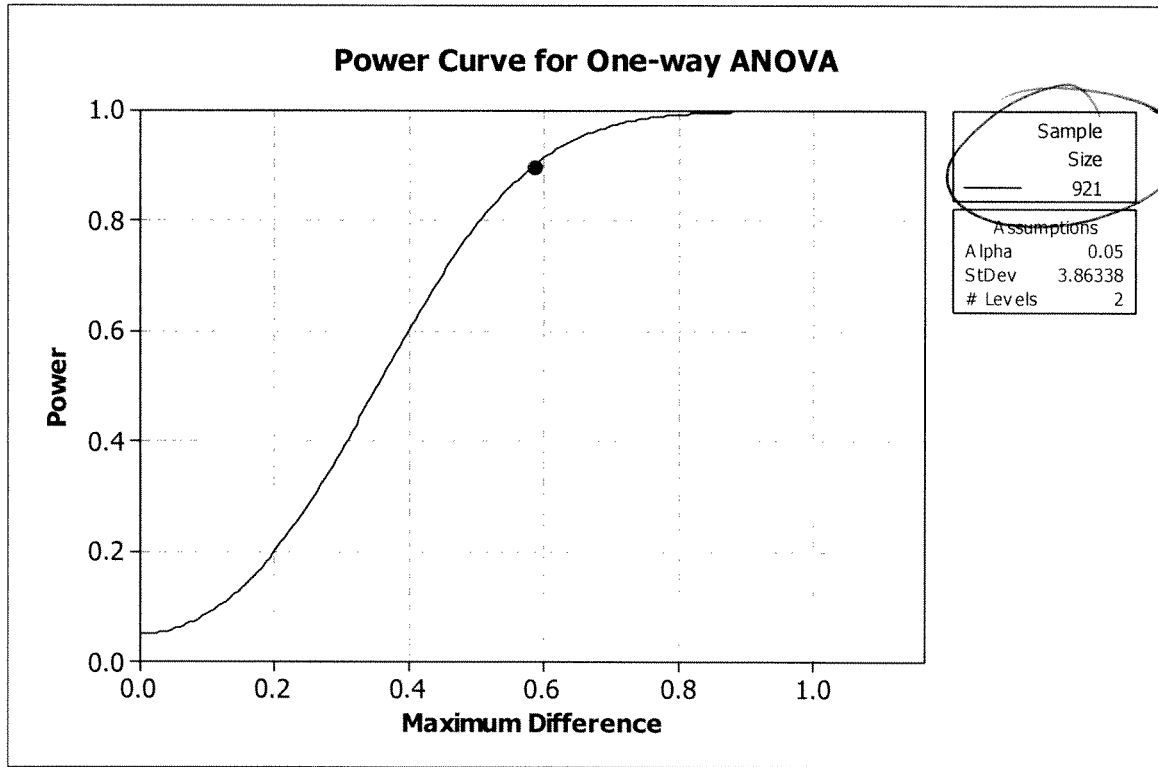
One-way ANOVA

Alpha = 0.05 Assumed standard deviation = 3.86338 Number of Levels = 2

SS Means	Sample Size	Target Power	Actual Power	Maximum Difference
0.170528	921	0.9	0.900112	0.584

$\beta = 0.10$

The sample size is for each level.  $\rightarrow n = 921$



```

MTB > Power;
SUBC> OneWay 2;
SUBC> Sample 60 100 500 1000;
SUBC> Power .9;
SUBC> Sigma 3.86338;
SUBC> GPCurve.
    
```

**Power and Sample Size**

One-way ANOVA

Alpha = 0.05 Assumed standard deviation = 3.86338 Number of Levels = 2

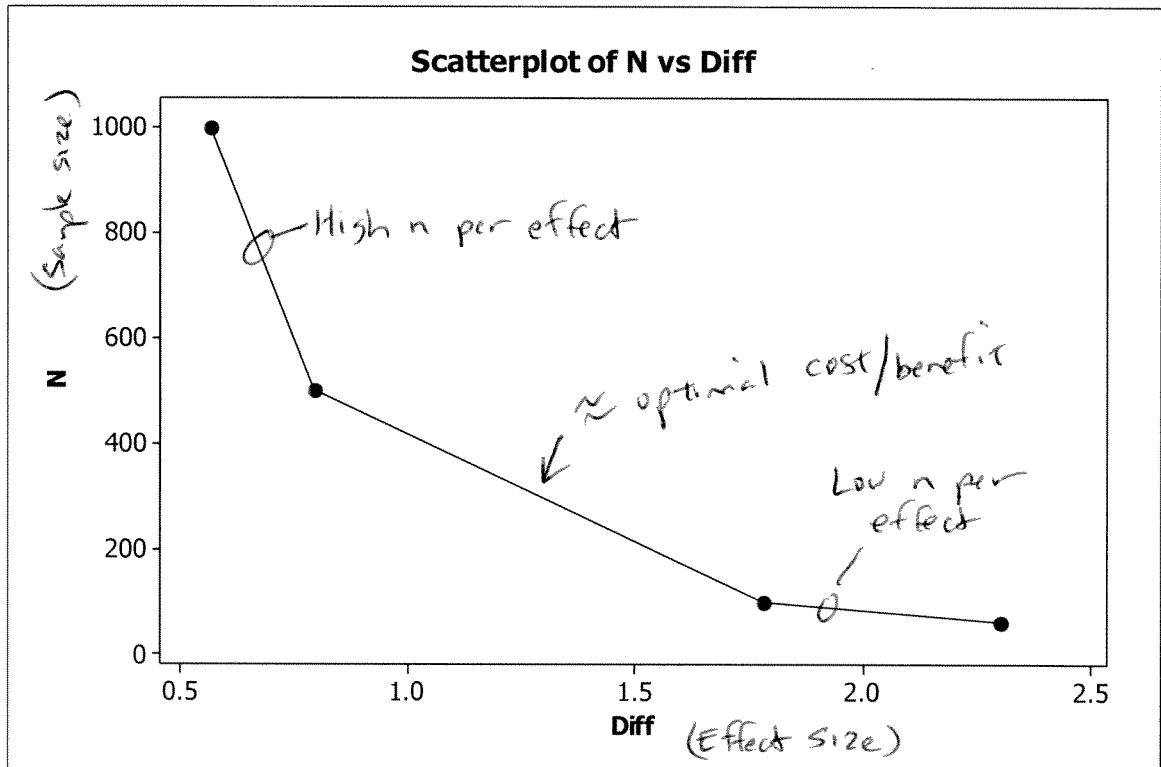
Sample Size	Power	SS Means	Maximum Difference
60	0.9	2.65710	2.30526
100	0.9	1.58367	1.77970
500	0.9	0.31427	0.79280
1000	0.9	0.15698	0.56032

The sample size is for each level.

*What sample sizes are needed to estimate different effect sizes?*

*Plot with scatter plot*

**Power Curve for One-way ANOVA**



*max Diff. Blank*

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Point estimates:

1) **If preliminary survey data are available:**

$$n \approx \left[ \frac{2s}{d} \right]^2$$

Where,  $d$  = width of desired absolute confidence interval and  $s$   
= standard deviation of preliminary sample

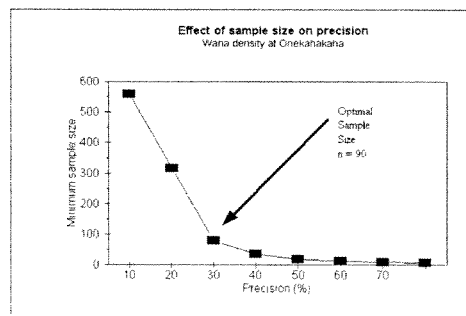
Example: Based on a preliminary sample urchins density at Onekahakaha was estimated at  $\bar{X}=7.95/m^2$  and  $s=12.5$ . Calculate sample size to estimate urchin density to within  $\pm 5$  urchins/ $m^2$  (desire 95% confidence interval of 2.95-12.95).

$$n \approx \left[ \frac{2s}{d} \right]^2 \approx \left[ \frac{2(12.5)}{5} \right]^2 \approx 25$$

At least 25 quadrats need to be sampled.

Criteria for selecting  $d$ :

1. Define absolute level based on prior knowledge (e.g.,  $\pm 10$  fish/ $m^2$ ).
2. Define relative precision based on established criteria (e.g.,  $\pm 10$  % of mean density).
3. Maximize cost effectiveness by looking at plot of precision vs. sample size:



2) **If no preliminary survey data are available:**

$$n \approx \left[ \frac{200CV}{r} \right]^2$$

Where,  $r$  = relative width of desired confidence interval (% of mean) and  $CV$  = coefficient of variation of system of study

Coefficients of variation for abundances estimates of some marine systems (after Krebs, 1989):

<u>System</u>	<u>CV</u>
Plankton	0.70
Grab samples	0.40
Shellfish	0.40
Fish	0.50-2.00

Example 1: Calculate sample size to estimate mean density of *Nerita (pipipi)* density to within  $\pm 10\%$ .

$$n \approx \left[ \frac{200CV}{r} \right]^2 \approx \left[ \frac{200(0.4)}{10} \right]^2 \approx 64$$

At least 64 quadrats need to be sampled.

Example 2: samples sizes for abundances of various marine organisms:

<u>Precision</u>	<u>Plankton</u>	<u>Shellfish</u>	<u>Fish (min)</u>	<u>Fish (max)</u>
5%	785	260	400	6400
10%	200	64	100	1600
15%	90	30	45	715
25%	35	10	20	260
50%	10	5	5	70

Differences among samples:

**Sample size required to estimate differences between sample means**

After Zar, 1996, P. 133 (eq. 8.22)

$$n \geq 2s^2 / d^2 * (T_{\alpha, v} + T_{\beta, v})^2$$

Where,  $s^2$  = sample variance;  $d^2$  = desired 95% confidence interval

		Estimated n			
		Kapoho	Puako	Molokini	Molokini
		Coral	Coral	Coral	Fish
	$s^2 =$	26.2	27.5	23.37	58.9
	$n =$	60	45	5209	18
Alpha = 0.05	$T_{\alpha, v} =$	2.00	2.01	1.96	2.10
Beta = 0.10	$T_{\beta, v} =$	1.67	1.68	1.65	1.73
$d^2$	2.5	2960	3301	2272	16327
	5	740	825	568	4082
	10	185	206	142	1020
	15	82	92	63	454
	20	46	52	36	255
	30	21	23	16	113
	40	12	13	9	64
	50	7	8	6	41
	60	5	6	4	28
	70	4	4	3	21

