CLAM SURVEYS AND MANAGEMENT IN BAR HARBOR

Field Ecology and Data Analysis: Final Project
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INTRODUCTION

Clams are one of the only marine resources that towns in Maine have the authority to manage. They have traditionally been a public resource, with resource management generally favoring recreational over commercial harvesting. This tradition of open access is joined in many areas by a concern for the conservation of flats and concern about over utilization. Bar Harbor's Shellfish Management Ordinance reflects these competing goals in its purpose "to establish a shellfish conservation program for the town of Bar Harbor that will ensure the protection and optimum utilization of shellfish resources within its limits." To better understand the resources they are managing and the results of management actions, the town's Clam Committee and others have sporadically surveyed various flats within town jurisdiction. We have pulled together these surveys not only to look for possible trends, but also to provide a comprehensive view of all surveys done and suggest how they can be improved to optimize the results of future surveying.

Table 1. Available Surveys

Location	Month	Year	Status	# of plots	# of clams	Data Collector
Clarks Cove	May	2001	Open	95	4	Chris
Hadley Point Left	Oct	2003	Open	33	24	Chris
Hadley Point Left	Nov	2003	Open	13	43	Steve
Hadley Point Right	Oct	2003	Seasonally Closed	37	46	Chris
Hadley Point Right	Nov	2003	Seasonally Closed	2	8	Steve
Hadley Point Right	Oct	2000	Seasonally Closed	66	125	MDI Highschool
Hadley Point Right	Oct	1999	Seasonally Closed?	71	497	Jane/Committee
Salisbury Cove	Sept	2000	Closed	11	160	MDI Highschool
Bar Harbor Bar	??	1999	Closed	n/a	50	Steve Katona
Bar Harbor Bar	May	2003	Closed	41	57	Jane

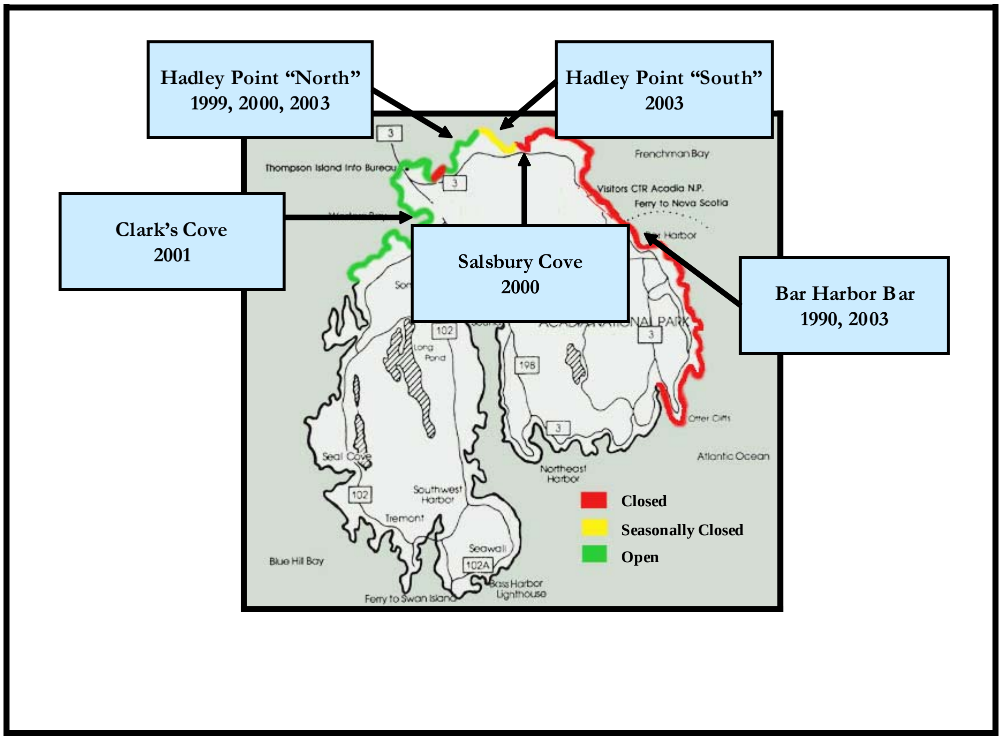


Fig. 1. Map of survey areas and years of surveys

METHODS

Most of the data has been collected following the guidelines in the Clam Management Handbook. It appears that all surveyors (except Katona 1990) counted and measured all clams encountered within 1x2 feet quadrats; however, the number and distribution of quadrats sampled at each site varies between surveys.

For the purposes of our analysis, we lumped the data from the two surveys on each side of Hadley's point in 2003 because they were taken within a one month period and there was no significant difference between the size frequency distributions obtained on each side (Mann-Whitney U test, p= 0.454 for the left side, p=0.235 for the right side).

We tested the size frequency data for normality and found that only half of our data sets fitted a Lilliefors distribution (see Table 2). Although we could use a parametric test to compare the normally distributed data sets, we chose a Kruskal Wallis test so that we would be able to compare all sites with a consistent test (since we were doing mostly pairwise comparisons, the test used, in effect, was a Mann-Whitney U-test).

None of the density data set fit a Poisson or Lillefors distribution, so we chose to use Mann-Whitney U-tests to assess this parameter.

Table 2. Results of Kolmogorov-Smirnov One Sample Tests on each data set			
Site	**Year**	**Probability that size frequency data fits a normal distribution**	**Probability that density data fits a Poisson distribution**
Bar Harbor Bar	2003	0.146	<0.0005
Bar Harbor Bar	1990	0.028	n/a*
Clarks Cove	2001	>0.9995	n/a*
Hadley Point Left	2003	0.634	<0.0005
Hadley Point Right	2003	0.11	0.001
Hadley Point Right	2000	<0.0005	n/a*
Hadley Point Right	1999	<0.0005	<0.0005
Salisbury Cove	2000	<0.0005	n/a*

* Only summary data on density is available (total number of clams per site / # of plots. The # of clams found in each plot was not available

RESULTS

Descriptive statistics for the size and density data are listed in Table 3-4 and Fig. 2.

We conducted a number of pair-wise Mann-Whitney U tests on both the size and density data. The p-values for comparisons of interest are listed in Table 5.

Table 3. Descriptive statistics for the size data								
	BHB1990	**BHB2003**	**CC2001**	**HPR1999**	**HPR2000**	**HPR2003**	**HPL2003**	**SS2000**
N of cases	50.00	57.00	4.00	497.00	125.00	54.00	67.00	160.00
Minimum	0.25	0.25	1.00	0.25	0.50	0.75	1.25	0.25
Maximum	2.75	3.25	2.00	3.50	3.00	3.50	3.25	3.00
Median	1.25	2.00	1.63	1.75	1.50	2.00	2.25	1.50
Mean	1.29	2.04	1.56	1.80	1.50	2.01	2.16	1.57
Stand. Dev	0.64	0.68	0.43	0.50	0.62	0.67	0.49	0.45

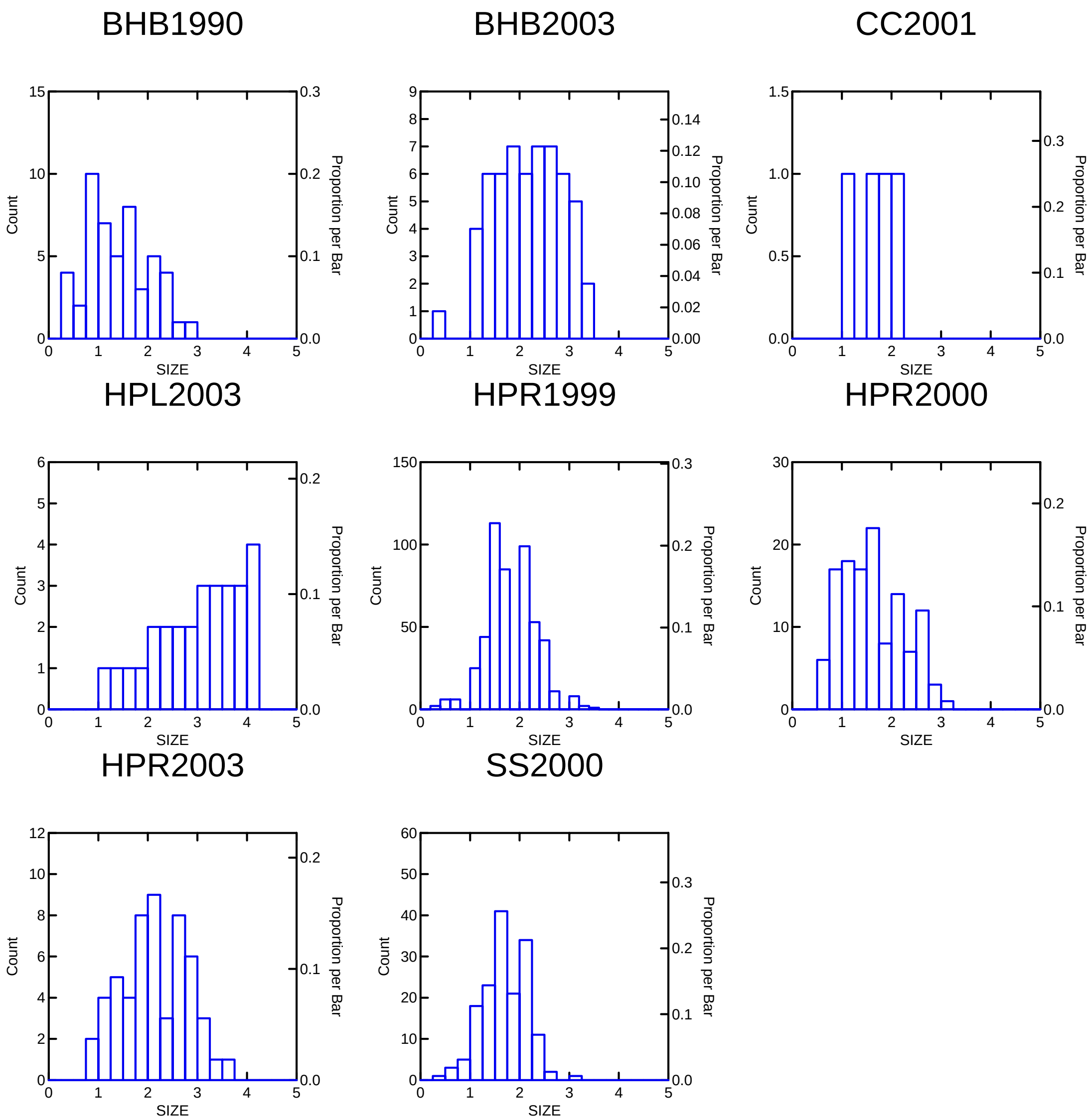


Fig. 2. Graphic display of the size frequency distributions of each survey.

Table 4. p-values for the Kruskal Wallis tests comparing the size frequencies in different surveys								
	BHB1990	**HPR1999**	**CC2001**	**BHB2003**	**HPR2000**	**SS2000**	**HPL2003**	**HPR2003**
BHB1990				<0.0005				
HPR1999					<0.0005			0.016
CC2001								
BHB2003								
HPR2000								<0.0005
SS2000								
HPL2003								0.213
HPR2003								

Table 5. p-values for the Kruskal Wallis tests comparing the size frequencies in areas of different management status				
	Open	**Seasonally Closed**	**Closed**	**Closed+ Seasonally Closed**
Open		<0.0005	<0.0005	<0.0005
Seasonally Closed			0.001	
Closed				
Closed+Seasonally Closed				

While we can detect differences in size frequency distribution between sites, we do not feel that these specific comparisons would be appropriate to use in management decisions until data show that size frequency distribution is a reliable indication of clam flat status. We also need to consider the effect of large settlement classes that could bias the survey toward a smaller mean size.

Table 6. Descriptive statistics for the density data

Site	Year	Mean Density	SD
Clarks Cove	2001	0.04	n/a*
Hadley Point Left	2003	0.73	1.232
Hadley Point Right	2003	0.92	1.588
Bar Harbor Bar	2003	1.39	2.268
Hadley Point Right	2000	1.89	n/a*
Hadley Point Left	2003	3.31	n/a*
Hadley Point Right	2003	4.00	n/a*
Hadley Point Right	1999	7.00	18.475
Salisbury Cove	2000	14.55	n/a*

* Only summary data on density is available (total number of clams per site / # of plots. The # of clams found in each plot was not available

Table 7. p-values for the Kruskal Wallis tests comparing the density data in different surveys				
	HPR1999	**HPR2003**	**HPL2003**	**BHB2003**
HPR1999		0.059	0.02	0.213
HPR2003			0.593	0.506
HPL2003				0.225
BHB2003				

Table 8. p-values for the Kruskal Wallis tests comparing the density data in areas of different management status			
	Seasonally Closed	**Closed**	**Closed+Seasonally Closed**
Open	0.03	0.113	0.072

We feel that the results we got for density are especially suspect as a few plots with what we feel to be an unreasonable number of clams (103 in one plot) pulled the overall mean density up for some sites. The comparison of open sites to those with closures is also not a solid analysis as for some of the categories we only had density data for a single site, and the four sites used span several sites and years.

POWER ANALYSIS

It is clear that the existing data is of varying quality and extensiveness, and some of it seems insufficient for rigorous statistical testing. In order to make recommendations about data collection in the future and to be able to evaluate the opportunities for analysis encompassed in existing data, we conducted a number of power analysis (that essentially were prospective because what we really are interested in asking is how many samples do we need to collect in the future in order to be able to detect biological or politically important effect size differences between flats with a certain level of accuracy, but can also use this to assess the extent to which existing data met the desired standards).

Before designing future survey activities, we should think about what effect sizes we are interested in detecting; what differences in size and density are important biologically and what differences are important from the resource users' perspective.

We also need to decide the accuracy with which we want to detect these differences and what level of risk we are willing to take in terms of making errors. We feel that in the case of clam management, the consequences of making a type I or type II error are equally negative. If a manager says that closing a flat makes a difference when it doesn't, they both make public resources unavailable (which represent lost income for clammers) and jeopardize their credibility as managers. If, on the other hand, they say that closing makes no difference when it does, they may not protect the resource adequately. In response to our concerns about these problems, we believe that the data collection should be designed so that we have an equal chance of making a type I vs. a type II error, i.e. that $\alpha=\beta=05$.

Figs. 3 and 5 show the amount of samples needed to be able to detect different effect size with a power of 0.95. Figs 4 and 6 and Table 9 compares the results of our power analysis with the existing data.

These graphs clearly indicate that the effort needed to achieve this power is much higher for density analyses than size frequency distribution (because the variation in the density is much higher than that of the size frequency data), and the existing data sets can show much smaller differences in size frequency distribution than density.

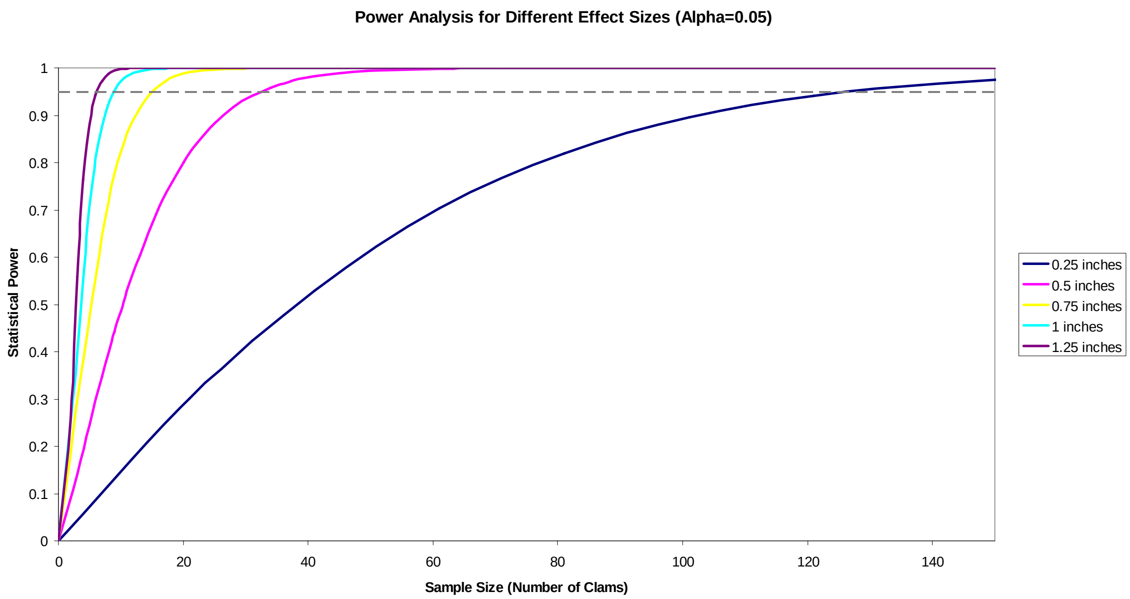
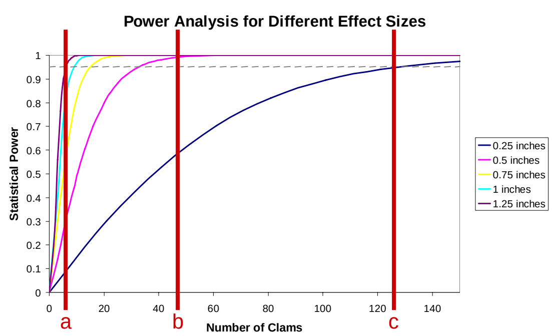


Fig. 3. Results of the power analysis for size frequency. Each line represents the relationship between the power at which a given size difference between two samples (as indicated in the legend to the right) can be detected with a certain sample size (number of clams). The intersection points of each of the colored curves and the stippled line indicates how many samples are needed to detect that size difference with a power of 0.95.



Site	# of Clams	Detectable Size Difference:
Clarks Cove 2001	4	>0.75 inches
a → Hadley Point Right 2003b	8	>0.75 inches
Hadley Point Left 2003a	24	>0.75 inches
b → Hadley Point Left 2003b	43	0.5 inches
Hadley Point Right 2003a	46	0.5 inches
Bar Harbor Bar 1990	50	0.5 inches
Bar Harbor Bar 2003	57	0.5 inches
c → Hadley Point Right 2000	125	<0.25 inches
Salisbury Cove 2000	160	<0.25 inches
Hadley Point Right 1999	497	<0.25 inches

Fig.4. Comparison of the power analysis and existing data for size frequency. It shows that only three of the surveys would have the power to detect a size difference of less than 0.25 clams.

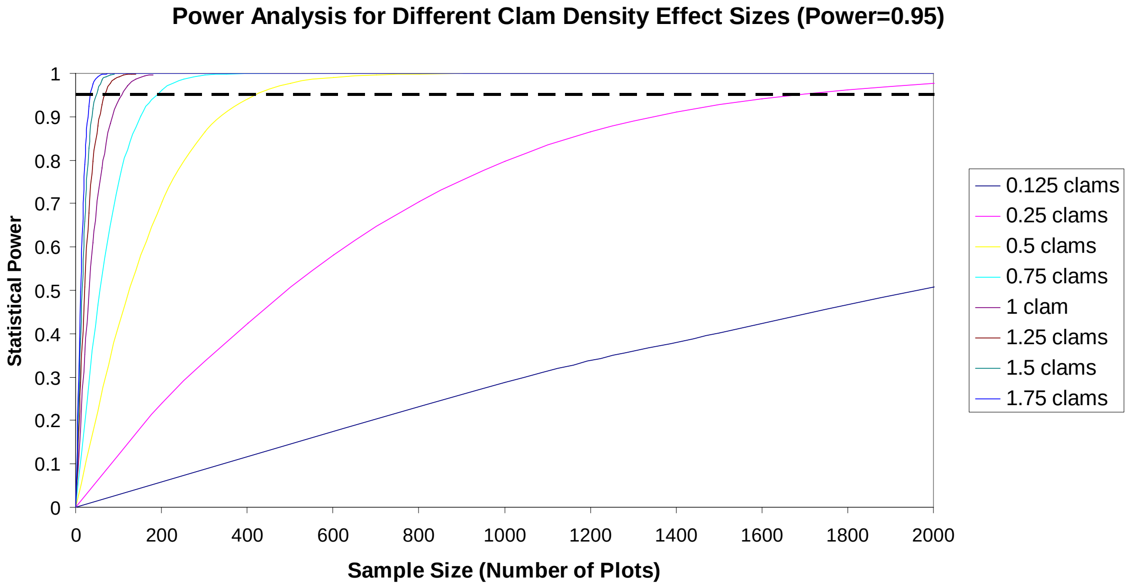
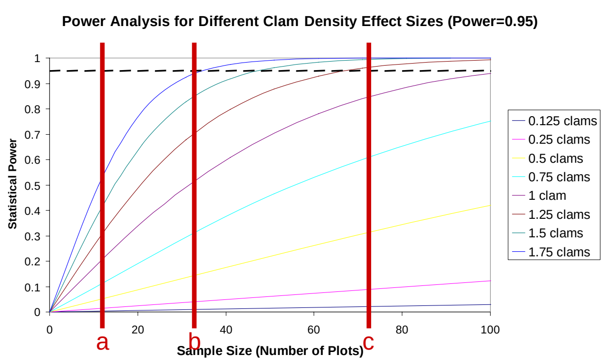


Fig. 5. Results of the power analysis for density. Each line represents the relationship between the power at which a given density difference between two samples (as indicated in the legend to the right) can be detected with a certain sample size (number of clams). The intersection points of each of the colored curves and the stippled line indicates how many samples are needed to detect that density difference with a power of 0.95.



Minimum Detectible Density Difference

	Survey ID	# of plots	Minimum Detectible Density Difference
	Hadley Point Right 2003b	2	
a →	Salisbury Cove 2000	11	70785 clams per acre
	Hadley Point Left 2003b	13	
b →	Hadley Point Left 2003a	33	43560 clams per acre
	Hadley Point Right 2003a	37	
	Bar Harbor Bar 2003	41	
	Hadley Point Right 2000	66	
c →	Hadley Point Right 1999	71	27225 clams per acre
	Clarks Cove 2001	95	

Fig. 6. Comparison of the power analysis and existing data for density. It shows that most of the surveys would only be able to detect a difference of above app. 45,000 clams per acre

Table 9. Minimum detectible effect size for each existing data set, calculated iteratively on the basis of the power analysis						
Site	Year	# of plots	# of clam	Minimum detectible size difference	Minimum detectable density at power=0.95 (# per plot)	Minimum detectable density at power=0.95 (bushels per acre)
Bar Harbor Bar	2003	41	57	0.5	1.75	38115
Clarks Cove	2001	95	4	1.5	1.25	27225
Hadley Point Left	2003	33	24	0.75	2	43560
Hadley Point Left	2003	13	43	0.5	3	65340
Hadley Point Right	2003	37	46	0.5	1.75	38115
Hadley Point Right	2003	2	8	1.25	n/a	n/a
Hadley Point Right	2000	66	125	0.5	1.5	32670
Hadley Point Right	1999	71	497	0.25	1.25	27225
Salisbury Cove	2000	11	160	0.25	3	65340

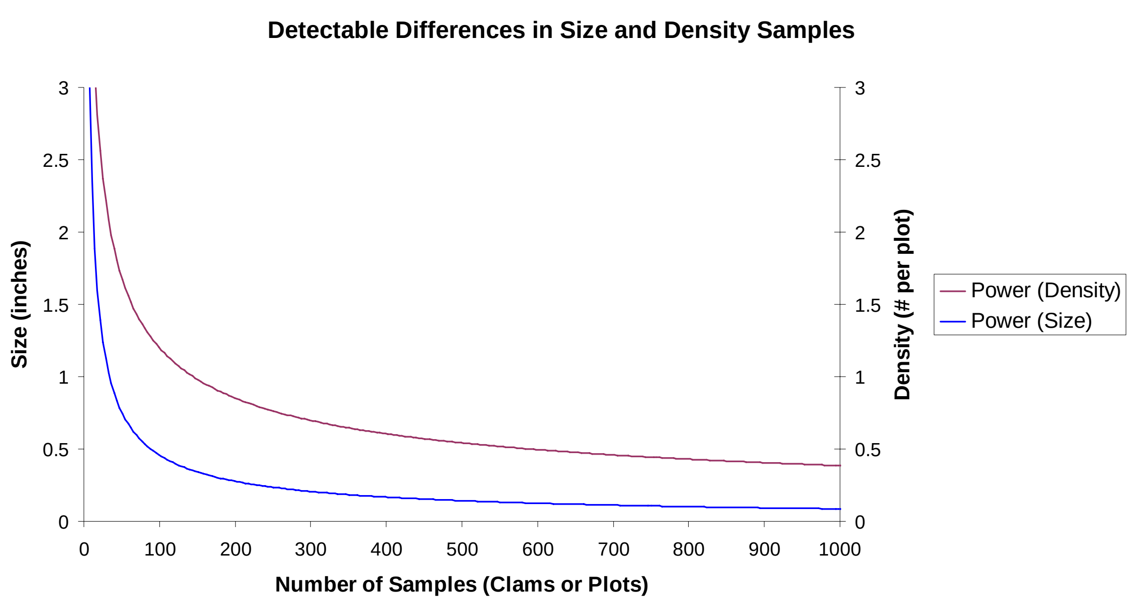


Fig. 7. Comparison of the number of samples needed to detect given differences in clam size and density. It is clear that much fewer samples are needed to detect a small difference in clam size compared to clam density.

Recommendations

We recommend the following to the Bar Harbor Clam Committee:

- The Committee should clearly define regular survey sites, preferably with GPS. This should help eliminate uncertainty over the consistency of survey areas for a given site and remove effects of different areas surveyed on data.

- The Committee should ensure/require that anyone who surveys uses the methods prescribed in The Maine Clam Handbook to make data collection more consistent.

- The Committee should use a standard data sheet (that we will provide) for all surveys to make data collection more consistent. There were many analyses we could not perform when surveys recorded different information.

- The Committee should consider whether management decisions could be based on size frequency data exclusively, because a much smaller sample size is needed for powerful tests for this parameter compared to density data (that has a higher variance)

- The Committee should decide on the effect sizes they consider important, and use the power analyses to set minimum sample sizes for surveys.

- The Committee should always survey an area before they open or close it to digging. Surveys should also be taken no less frequently than one per year following the action, until a time when any effects have leveled out. This is the only way to see if closing flats affects the abundance or relative size distribution of clams, and how long effects last. An example would be surveying the right side of Hadley Point biannually, once towards the end of the seasonal closure (June) and again towards the end of the main digging season in late fall.

- While community outreach is not an express mission of the committee, it has served a valuable function. We do not feel that our recommendations in any way exclude the involvement of community members, but rather will make the data they collect more consistent and valuable to the committee. Our recommendations are to encourage a commitment to consistent minimum effort on the part of the committee, but should not discourage additional effort.