SETTING THE CONFIDENCE INTERVAL AROUND THE TOTAL INVENTORY ESTIMATE FOR A STAND-BASED INVENTORY

Steve Fairweather
Mason, Bruce & Girard, Inc.
Portland, OR

Timber Measurements Society, 2011

MB&G

The Basics -

- **The ownership has been divided into stands, and every stand carries an estimated inventory**

The Basics -

- The ownership has been divided into stands, and every stand carries an estimated inventory
- **The inventory estimate for a stand may be based on -**
  - **a recent cruise,**
  - **an older cruise that has been grown to the present point in time,**
  - **an average for stands in the same stratum,**
  - **an assigned value,**
  - **"inherited" data,**
  - **…. and more.**

The Problem -

- **Because of the different types of stand estimates, traditional formulas for estimating the confidence interval don't apply**

The Problem -

- Because of the different types of stand estimates, traditional formulas for estimating the confidence interval don't apply

A Solution -

- **We can use simulation to derive a confidence interval**

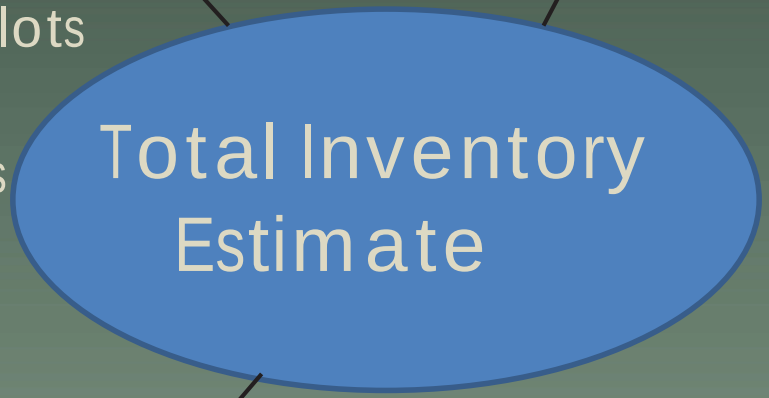
The Problem -

- Because of the different types of stand estimates, traditional formulas for estimating the confidence interval don't apply

A Solution -

- We can use simulation to derive a confidence interval
- **PLUS – we can use simulation to answer many "what-if" questions about inventory policy and design**

SETTING A CONFIDENCE INTERVAL FOR A STAND-BASED INVENTORY



Cruise Policies

– how often to cruise a stand?

- how many plots in a stand?

- which stands should be cruised?

Stratification

– what is the value of careful and accurate stratification?

- can "expansion" play a role in developing the inventory estimate?

Growth Modeling - what is the impact of "growing" a stand to the current point in time, as an alternative to cruising the stand?

- what if my growth model is biased ?

Simulation Basics -

- **Set up a population of interest with known attributes**

Simulation Basics -

- Set up a population of interest with known attributes
- **Apply our estimation methodology to the population, and see how close our estimate is to the true (known) value of the attribute**

Simulation Basics -

- Set up a population of interest with known attributes
- Apply our estimation methodology to the population, and see how close our estimate is to the true (known) value of the attribute
- **Repeat Step 2 many times, and track the variability (or range) of our estimates as they relate to the true value of the attribute**

Simulation Basics -

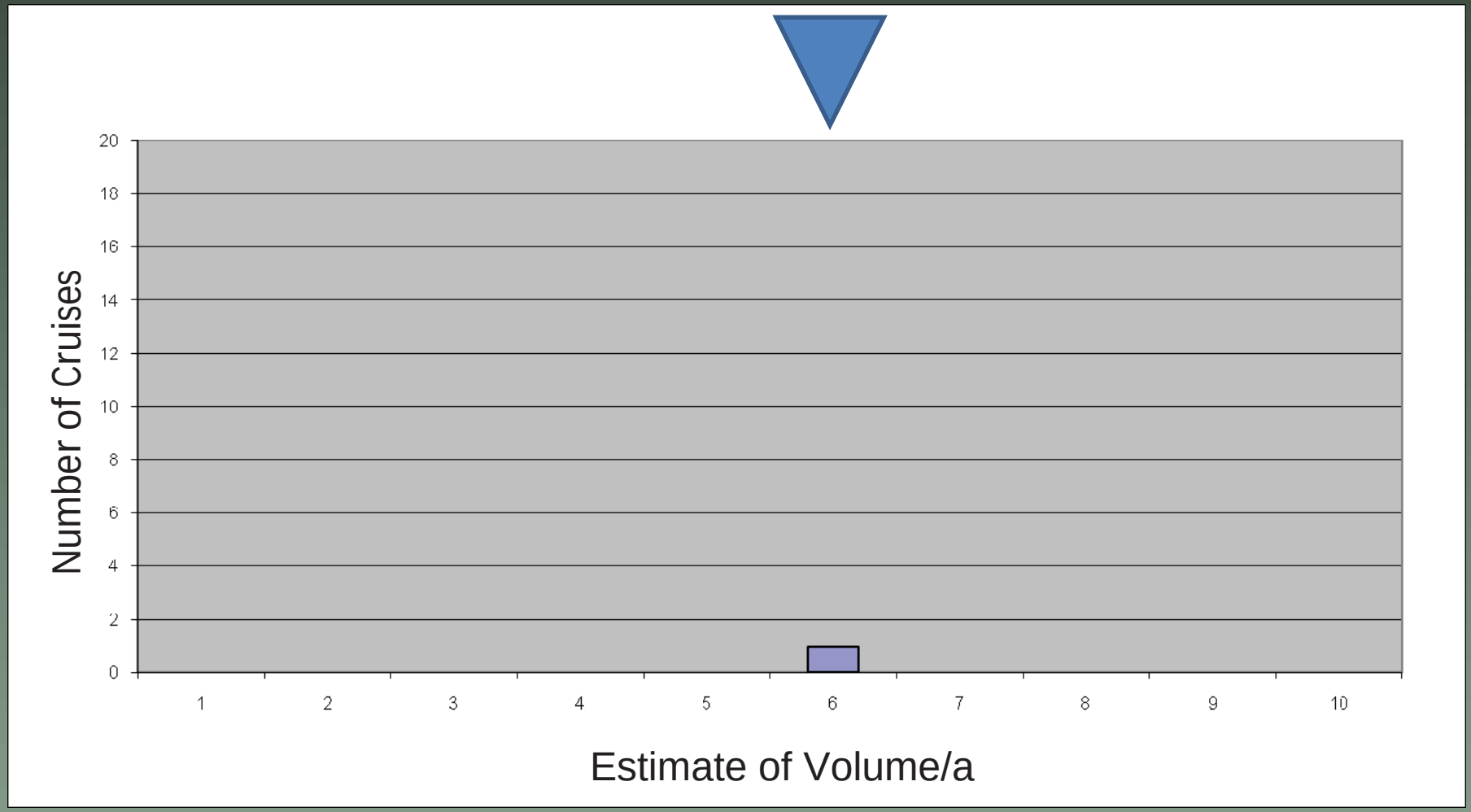
- Set up a population of interest with known attributes
- Apply our estimation methodology to the population, and see how close our estimate is to the true (known) value of the attribute
- Repeat Step 2 many times, and track the variability (or range) of our estimates as they relate to the true value of the attribute
- **Quantify how often our estimate is within +/- X % of the true population value.**

SETTING A CONFIDENCE INTERVAL FOR A STAND-BASED INVENTORY

We could use a physical model to do the simulation –

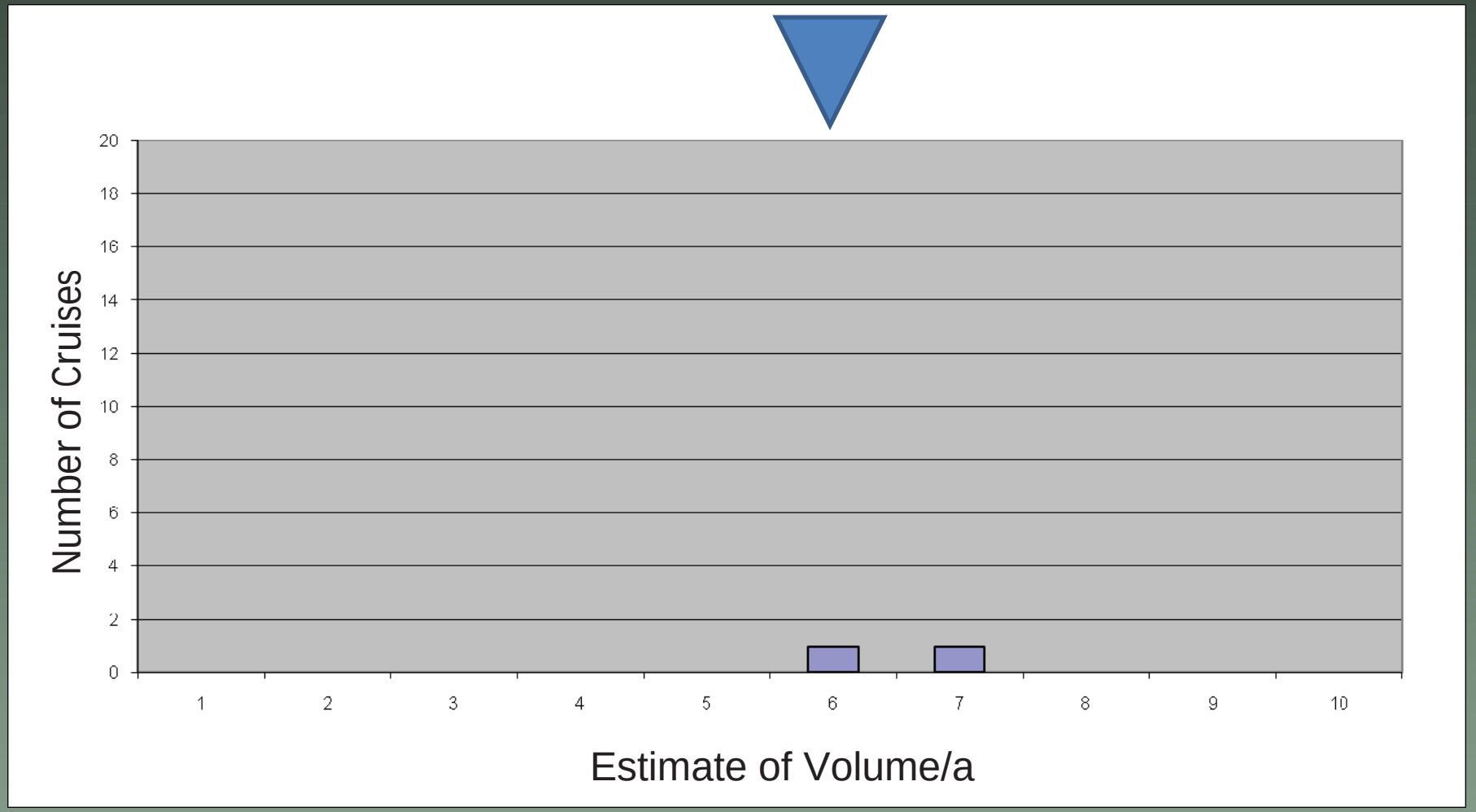
... but a mathematical model provides more flexibility.

TRUE VOLUME = 5.09; CV = 50%; n = 3; CRUISES = 1



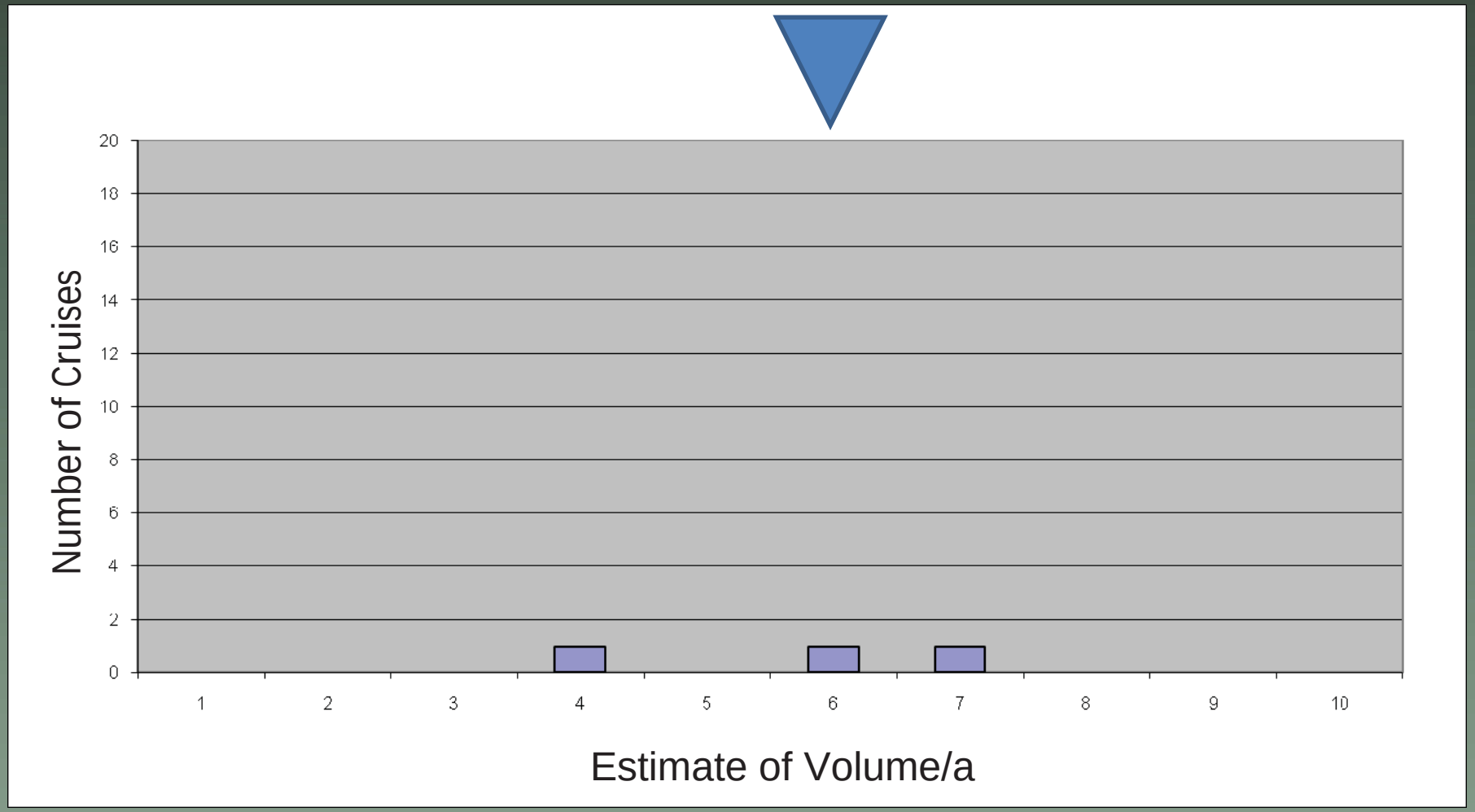
MB&G

TRUE VOLUME = 5.09; CV = 50%; n = 3; CRUISES = 2



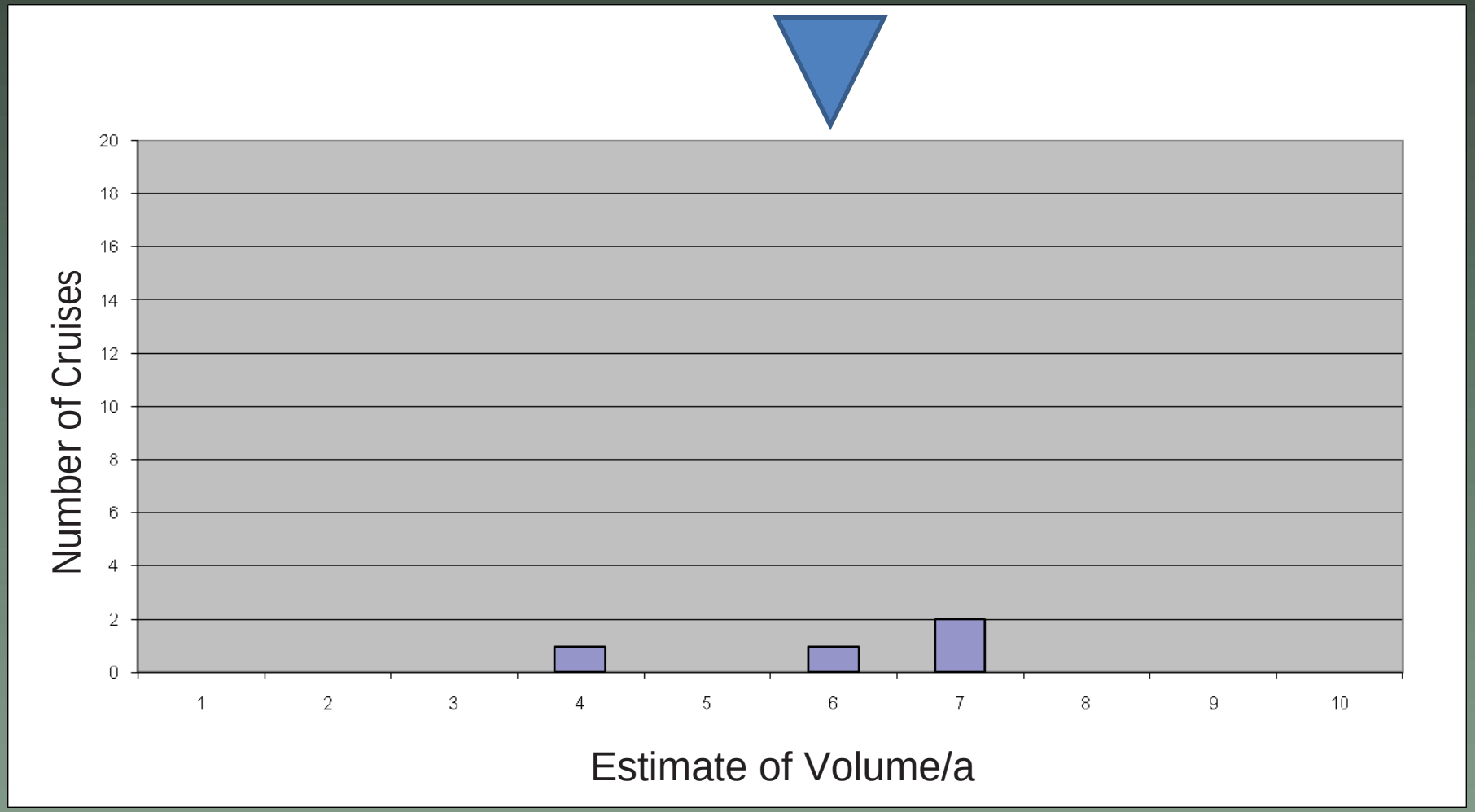
MB&G

TRUE VOLUME = 5.09; CV = 50%; n = 3; CRUISES = 3



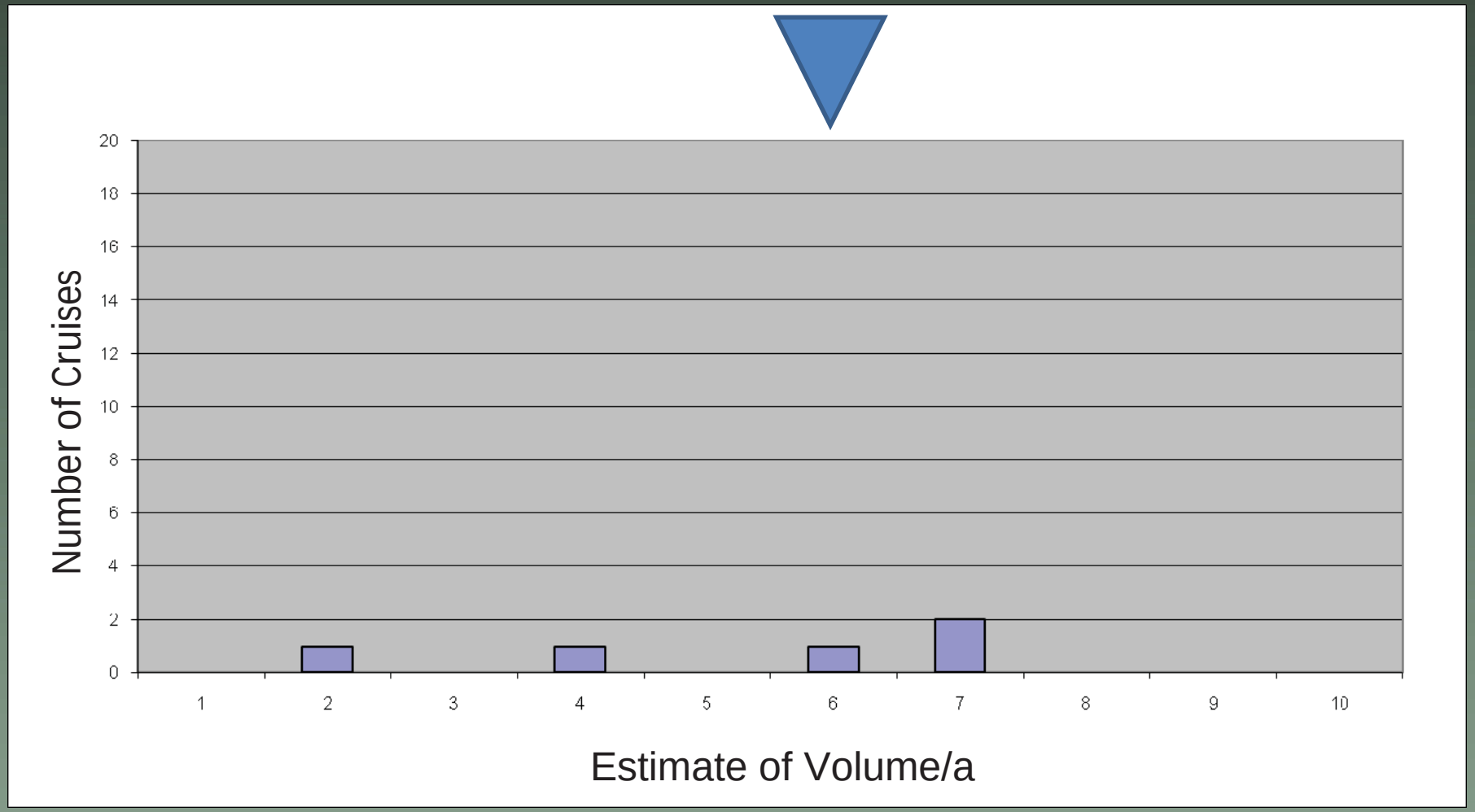
MB&G

TRUE VOLUME = 5.09; CV = 50%; n = 3; CRUISES = 4



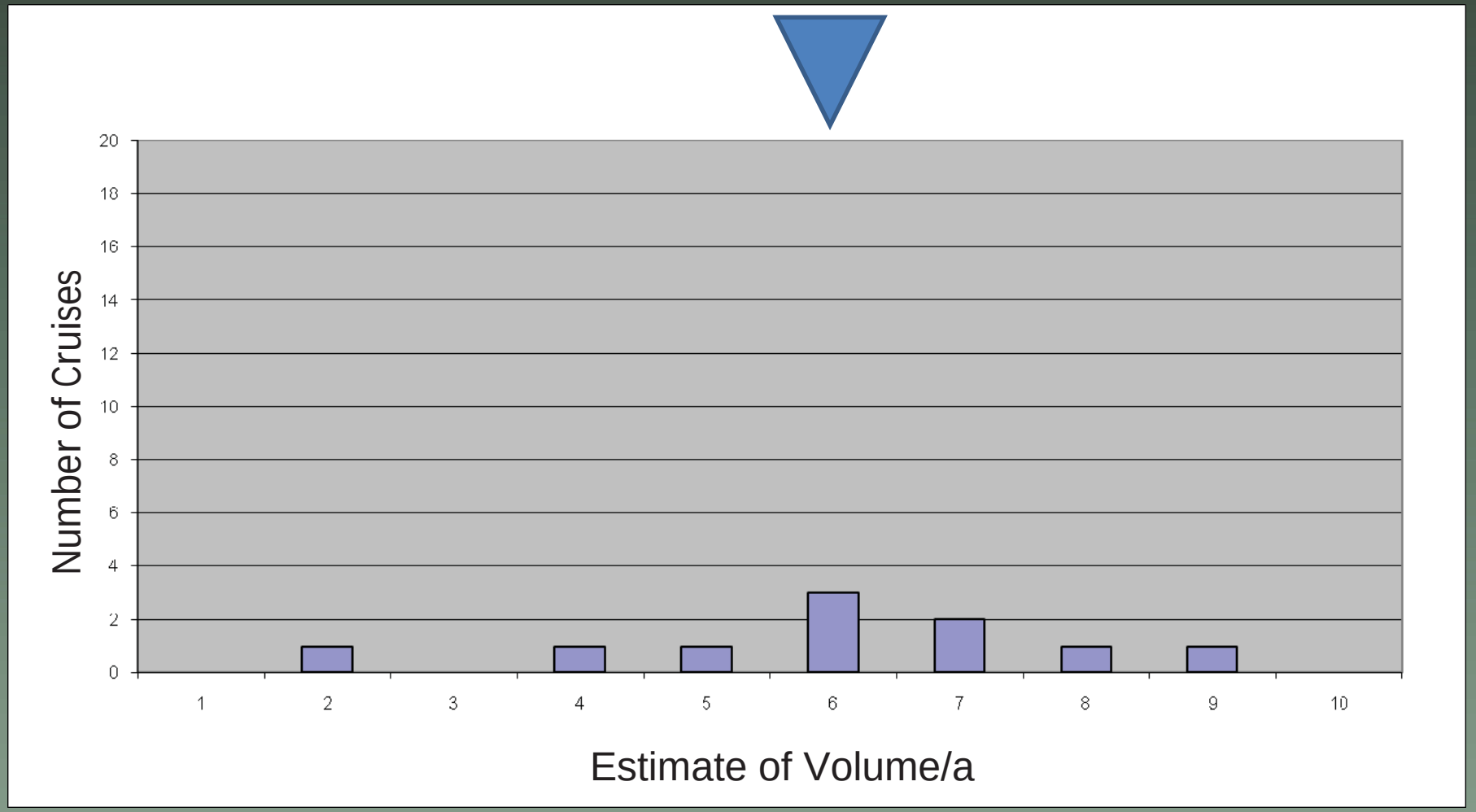
MB&G

TRUE VOLUME = 5.09; CV = 50%; n = 3; CRUISES = 5



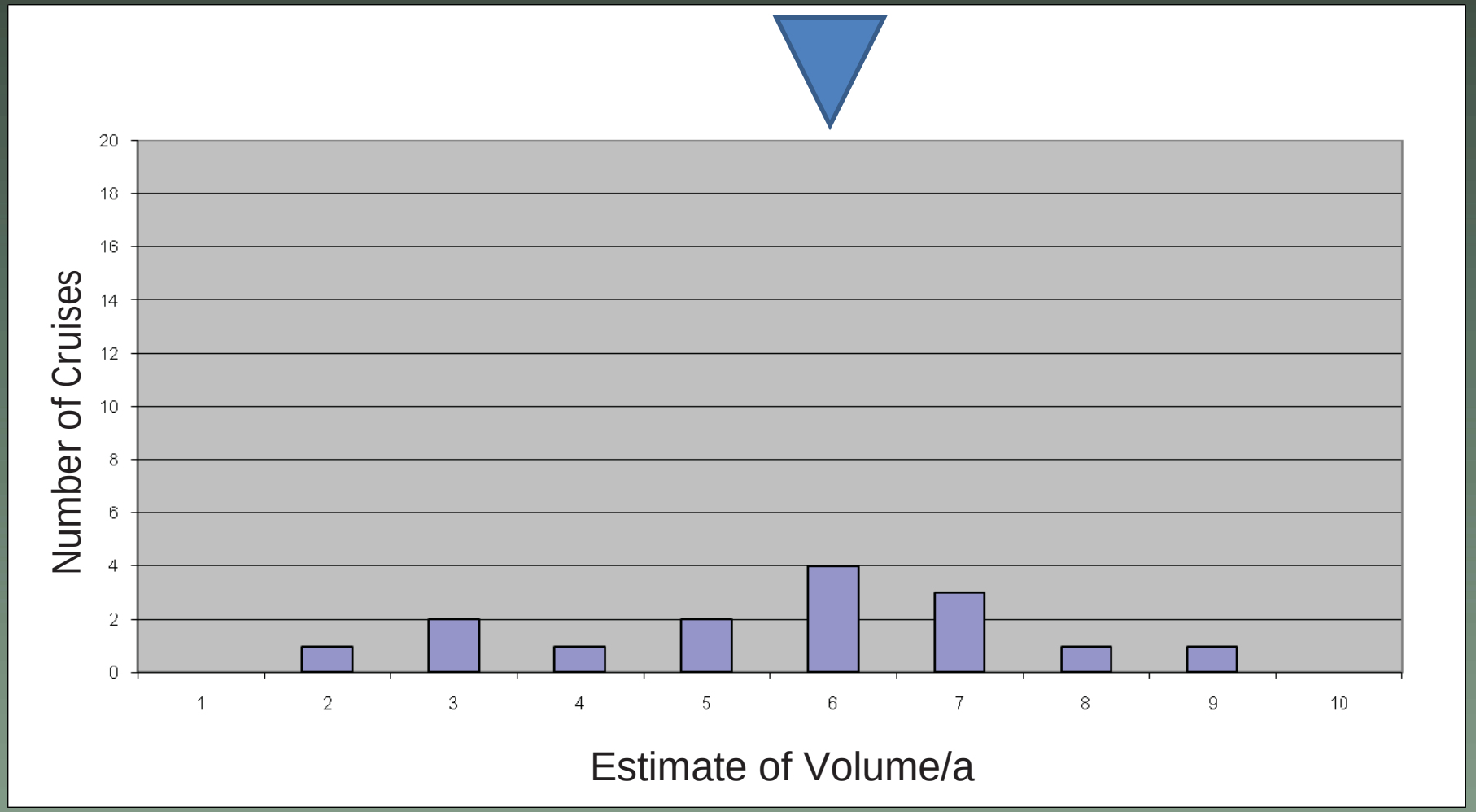
MB&G

TRUE VOLUME = 5.09; CV = 50%; n = 3; CRUISES =10



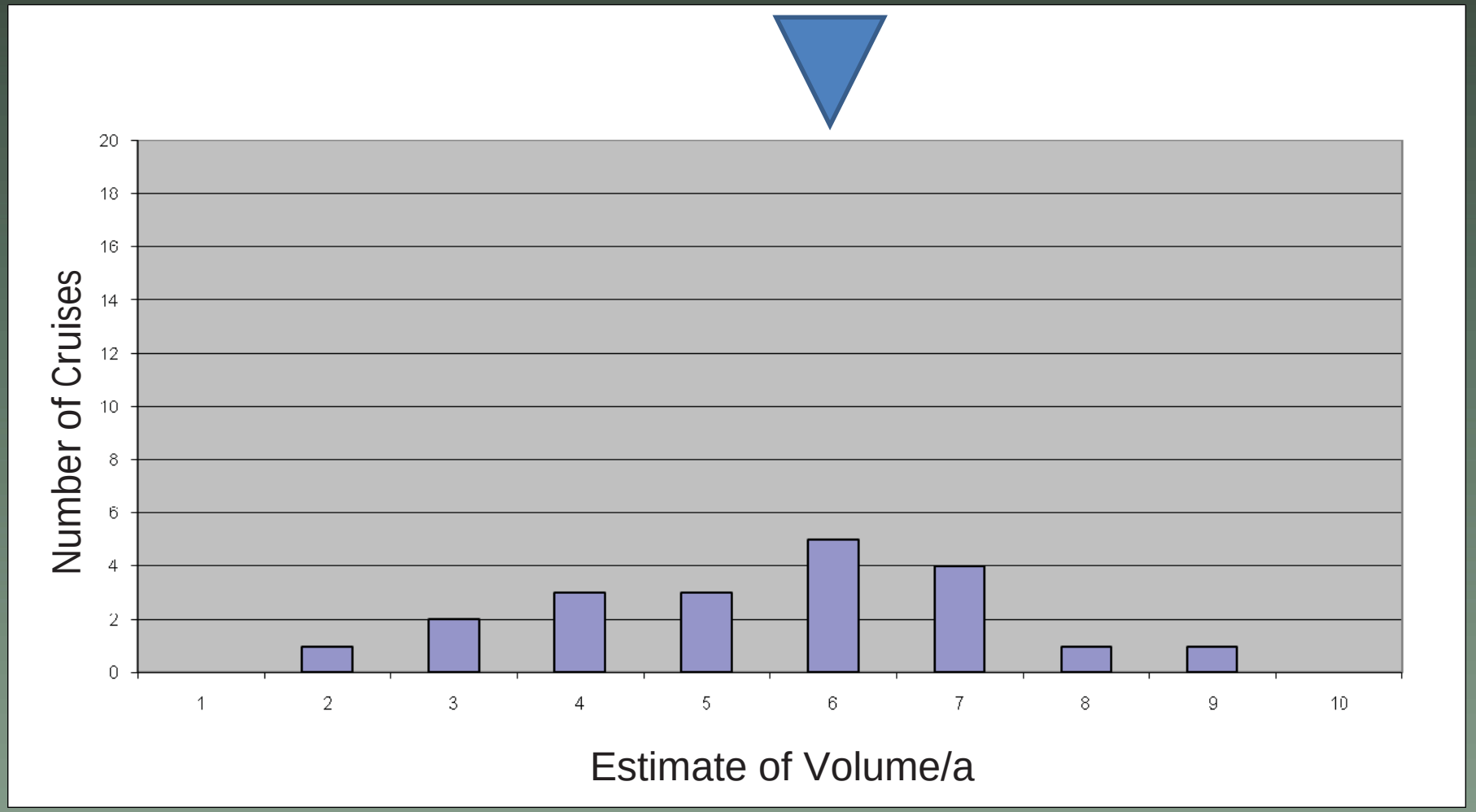
MB&G

TRUE VOLUME = 5.09; CV = 50%; n = 3; CRUISES =15



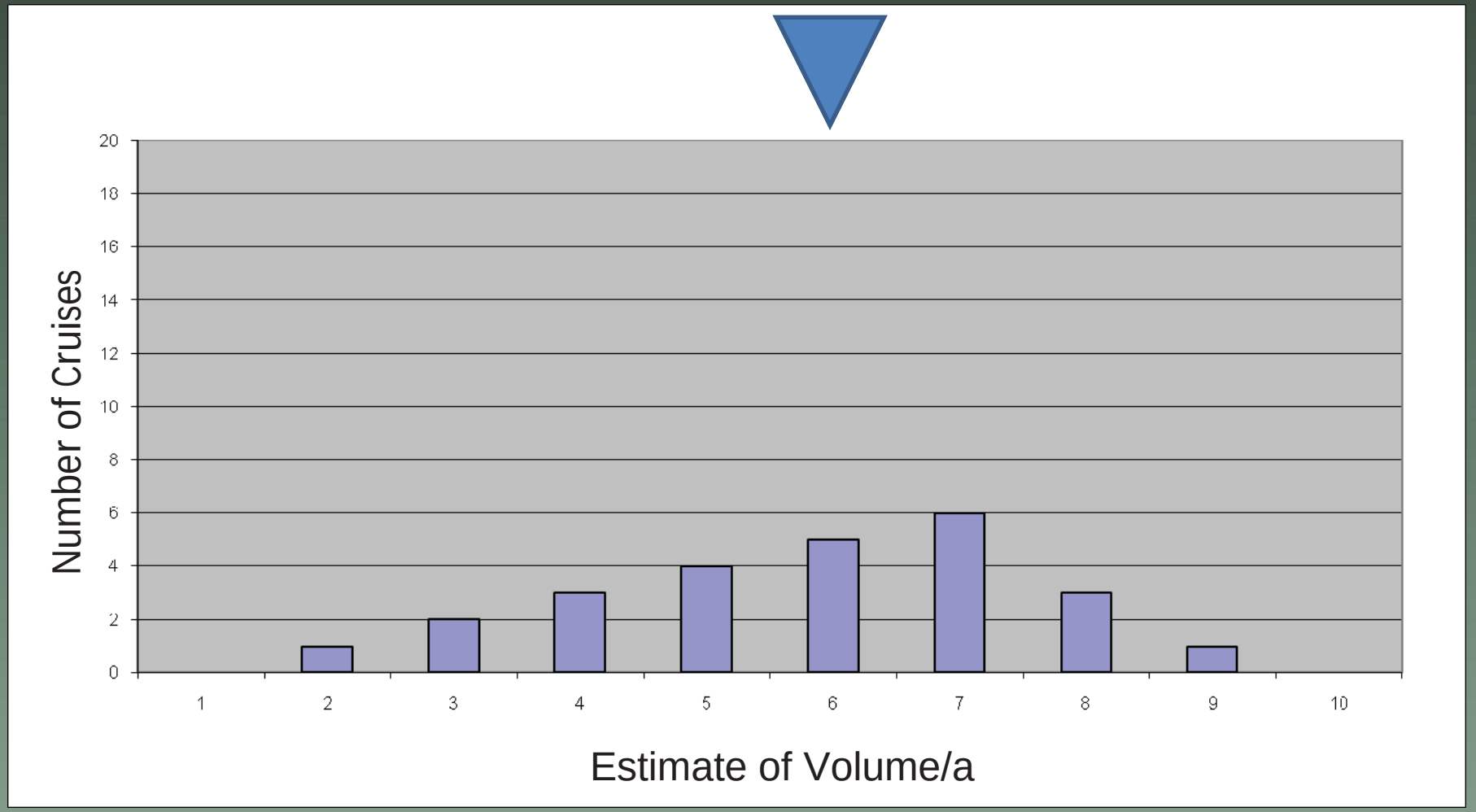
MB&G

TRUE VOLUME = 5.09; CV = 50%; n = 3; CRUISES =20



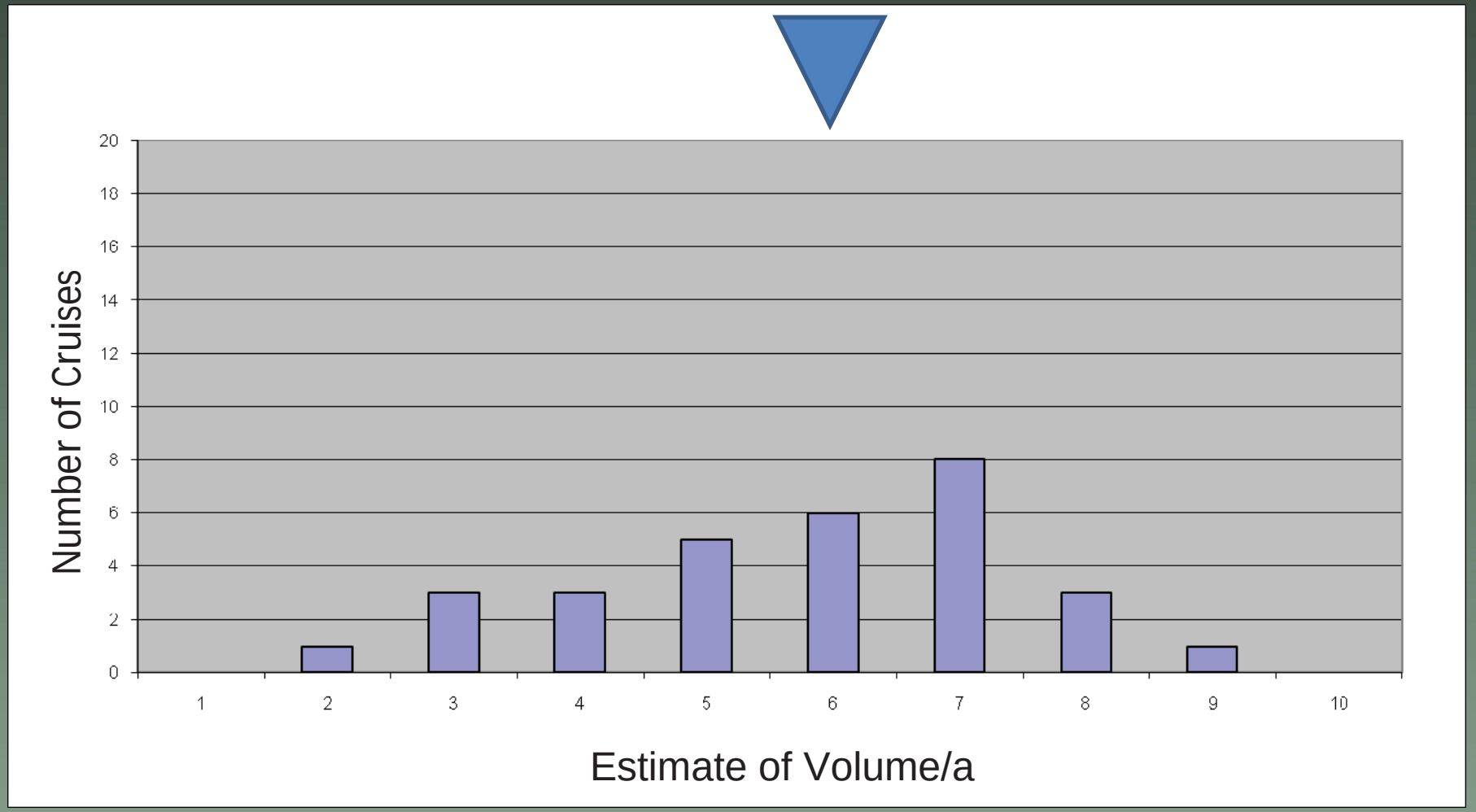
MB&G

TRUE VOLUME = 5.09; CV = 50%; n = 3; CRUISES =25



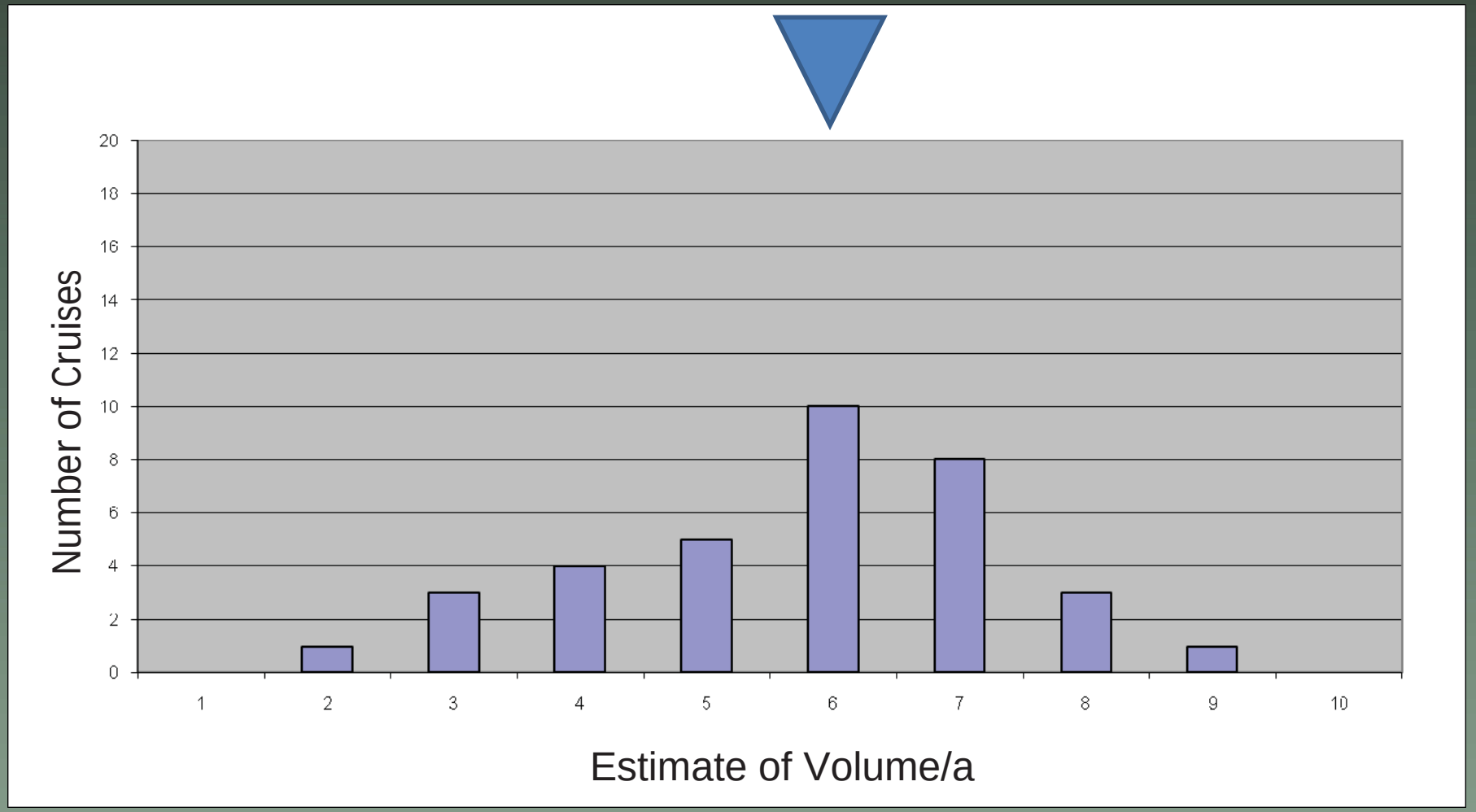
MB&G

TRUE VOLUME = 5.09; CV = 50%; n = 3; CRUISES =30



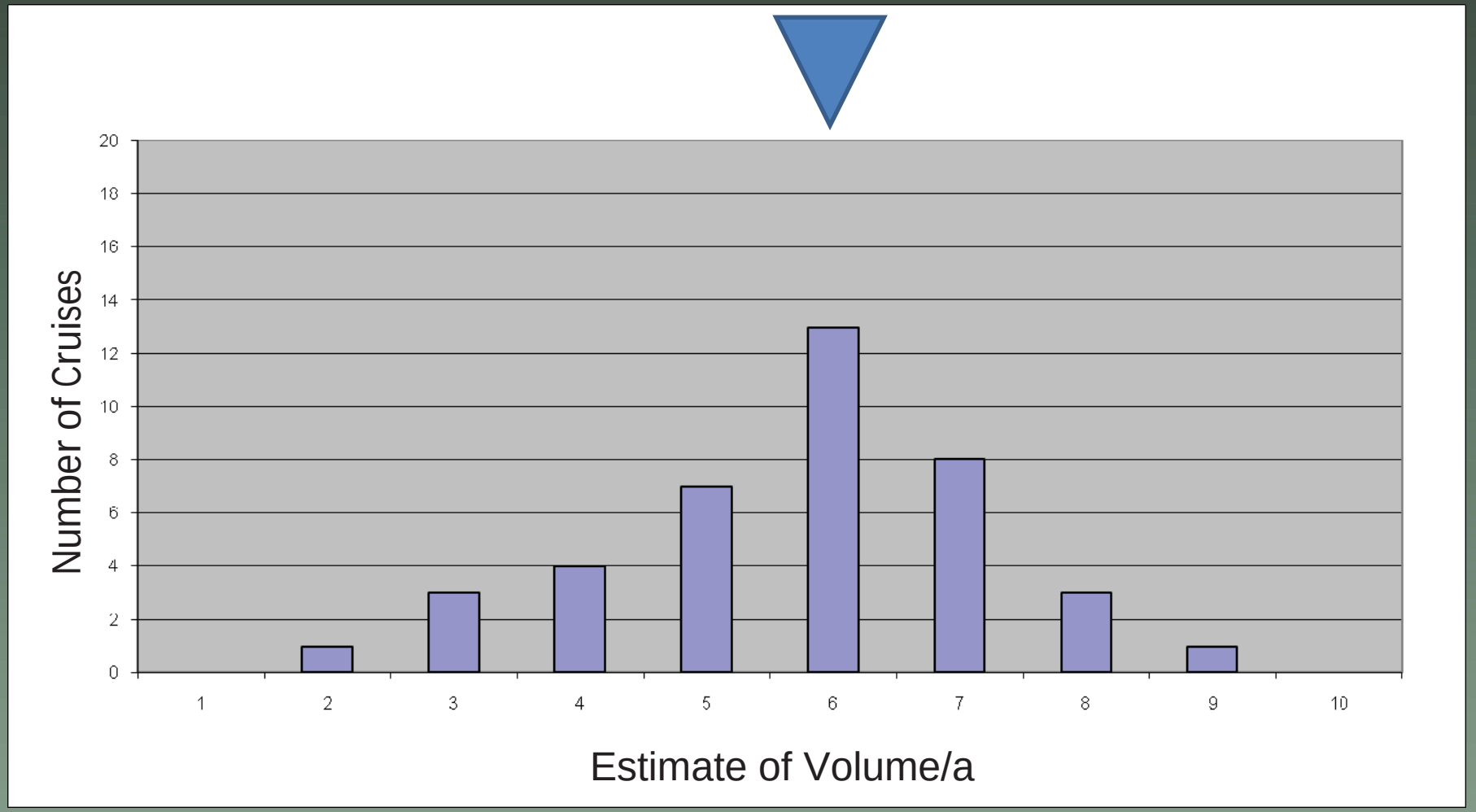
MB&G

TRUE VOLUME = 5.09; CV = 50%; n = 3; CRUISES =35



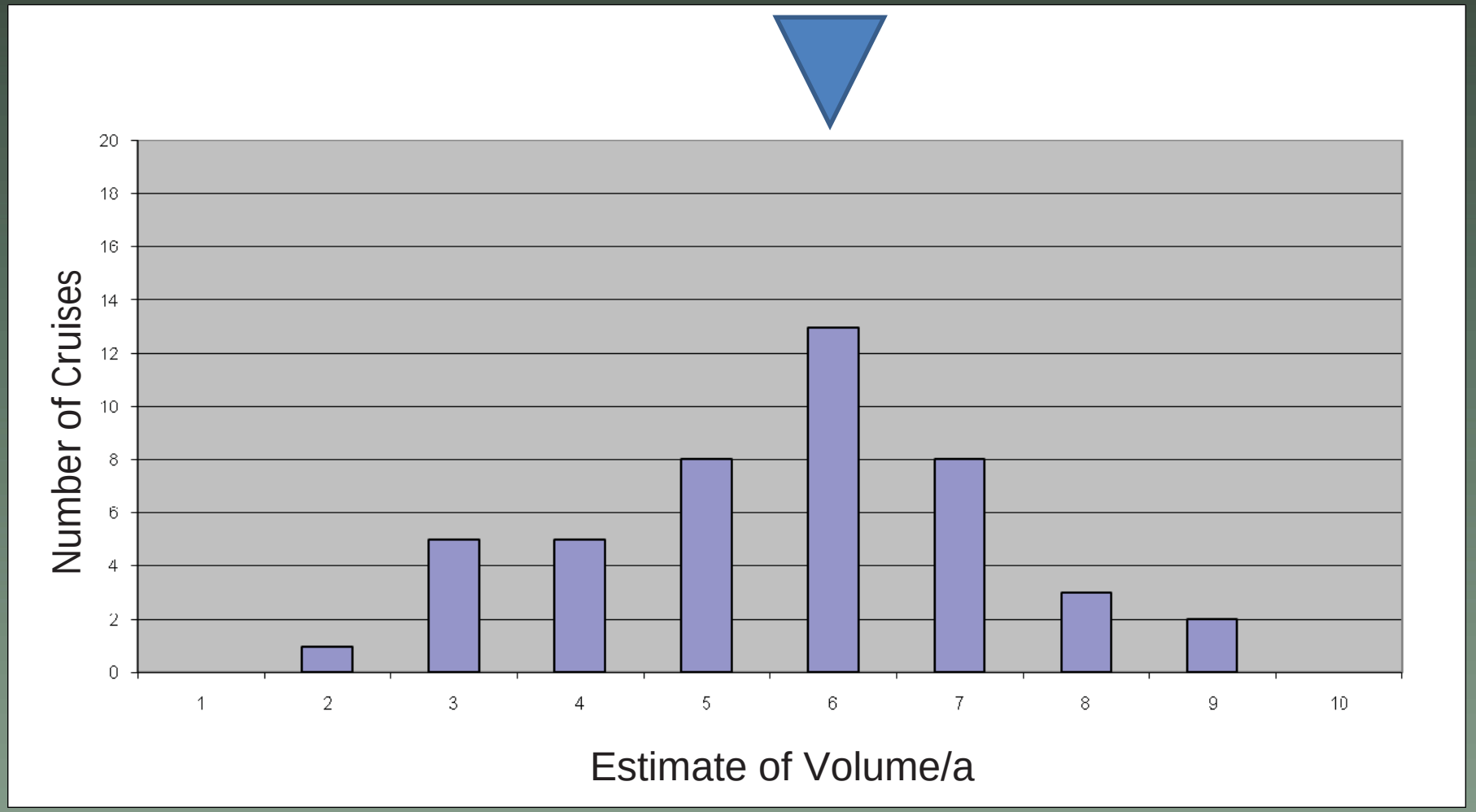
MB&G

TRUE VOLUME = 5.09; CV = 50%; n = 3; CRUISES =40



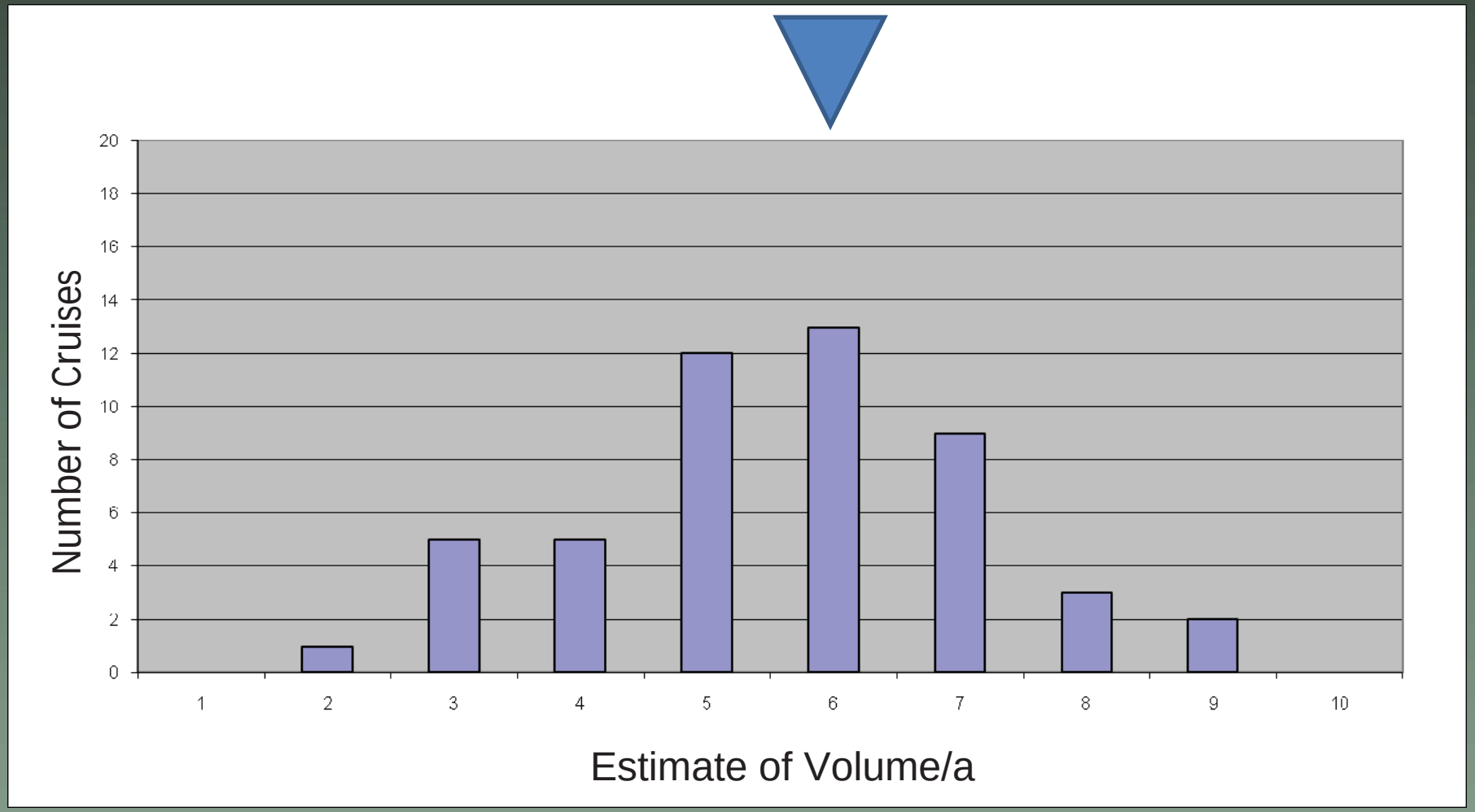
MB&G

TRUE VOLUME = 5.09; CV = 50%; n = 3; CRUISES =45



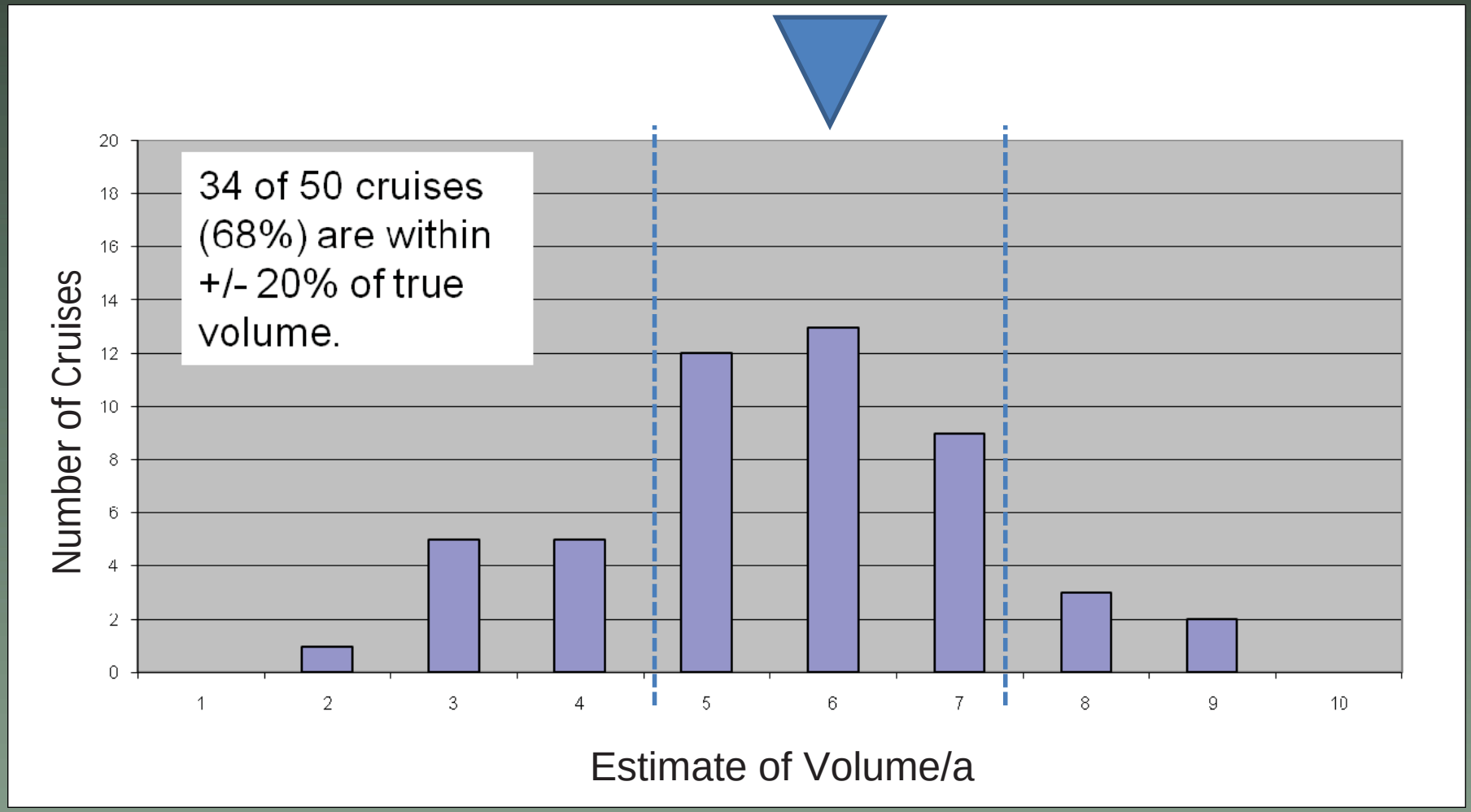
MB&G

TRUE VOLUME = 5.09; CV = 50%; n = 3; CRUISES =50



MB&G

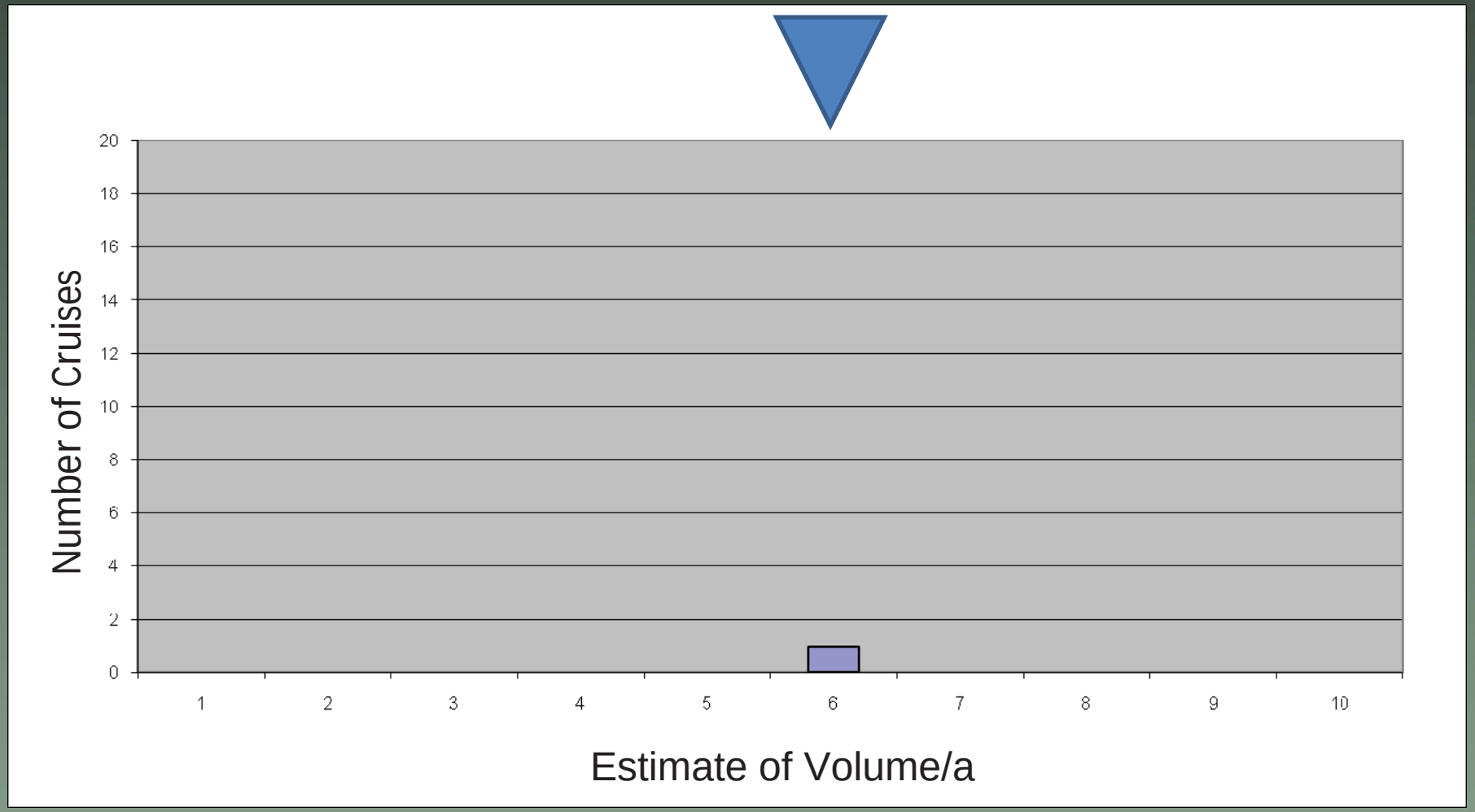
TRUE VOLUME = 5.09; CV = 50%; n = 3; CRUISES =50



MB&G

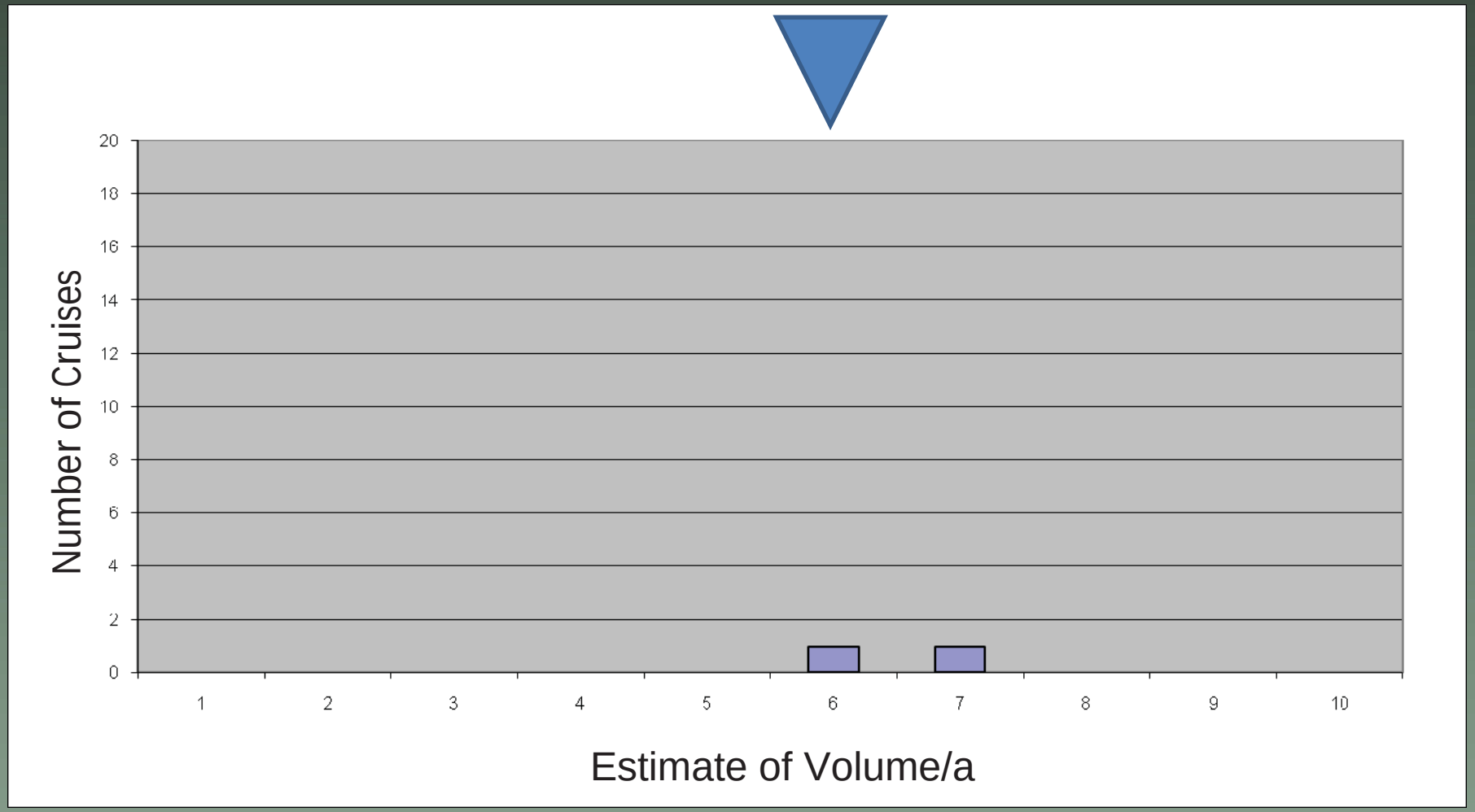
What if we changed the number of plots to 6? -

TRUE VOLUME = 5.09; CV = 50%; n = 6; CRUISES = 1



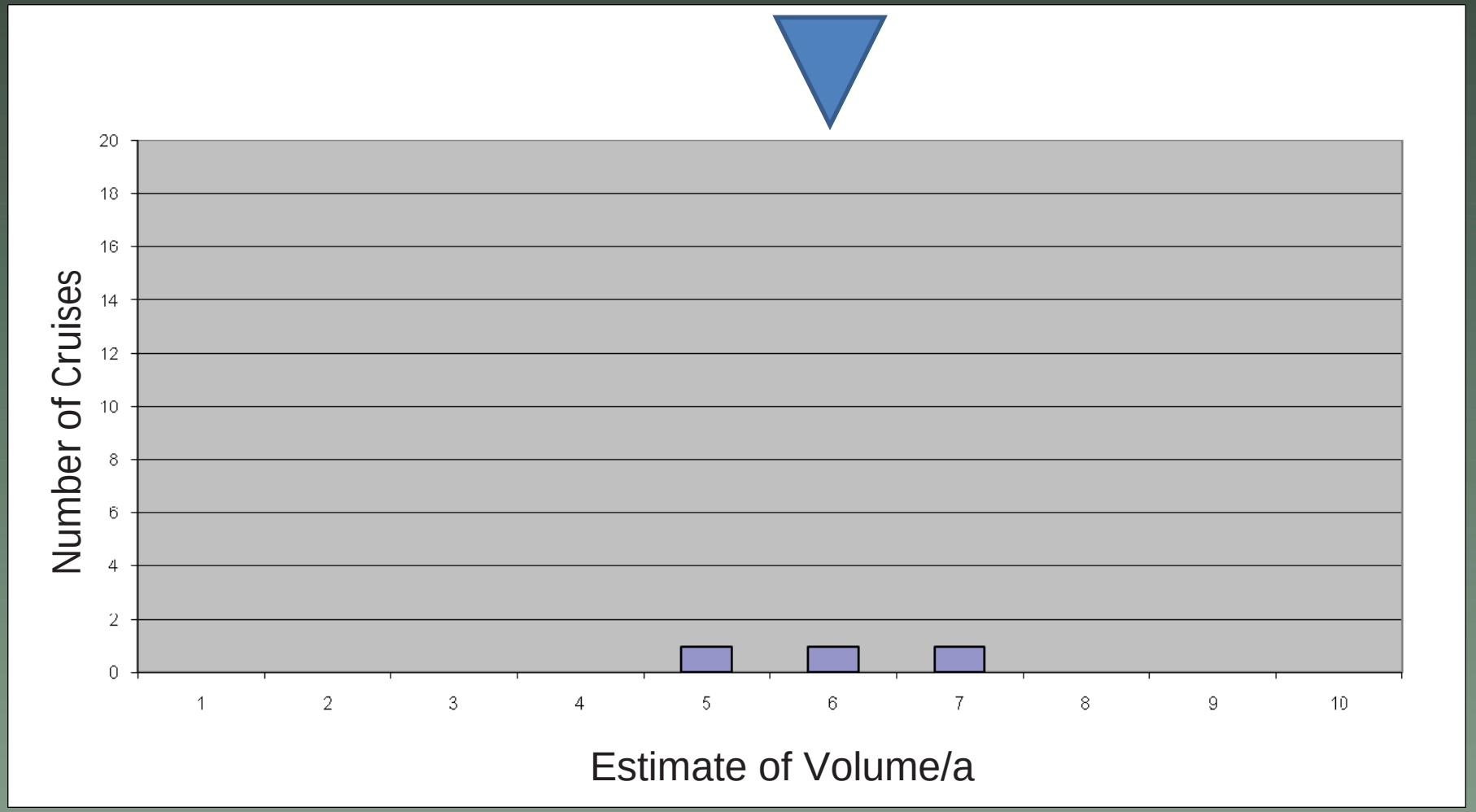
MB&G

TRUE VOLUME = 5.09; CV = 50%; n = 6; CRUISES = 2



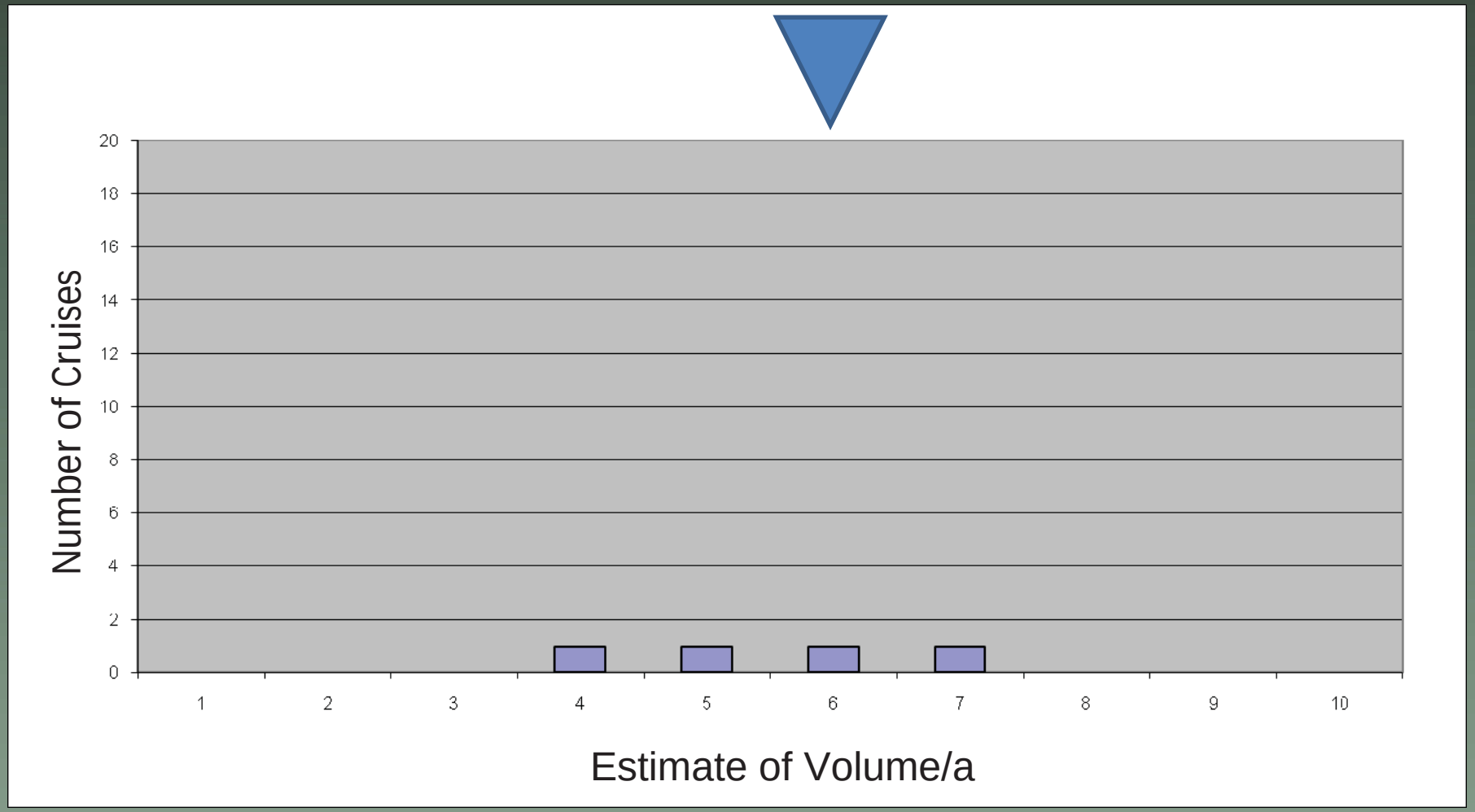
MB&G

TRUE VOLUME = 5.09; CV = 50%; n = 6; CRUISES = 3



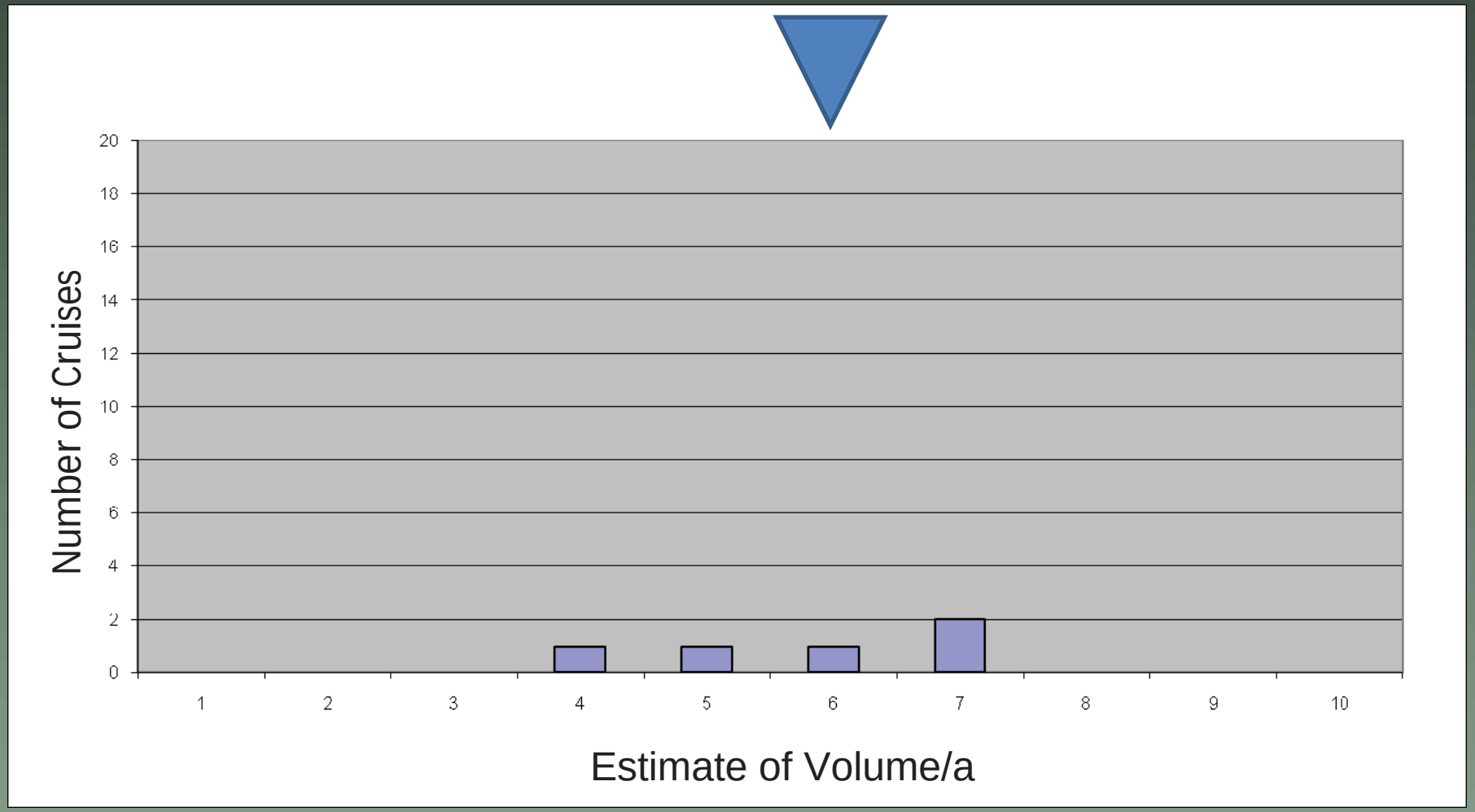
MB&G

TRUE VOLUME = 5.09; CV = 50%; n = 6; CRUISES = 4



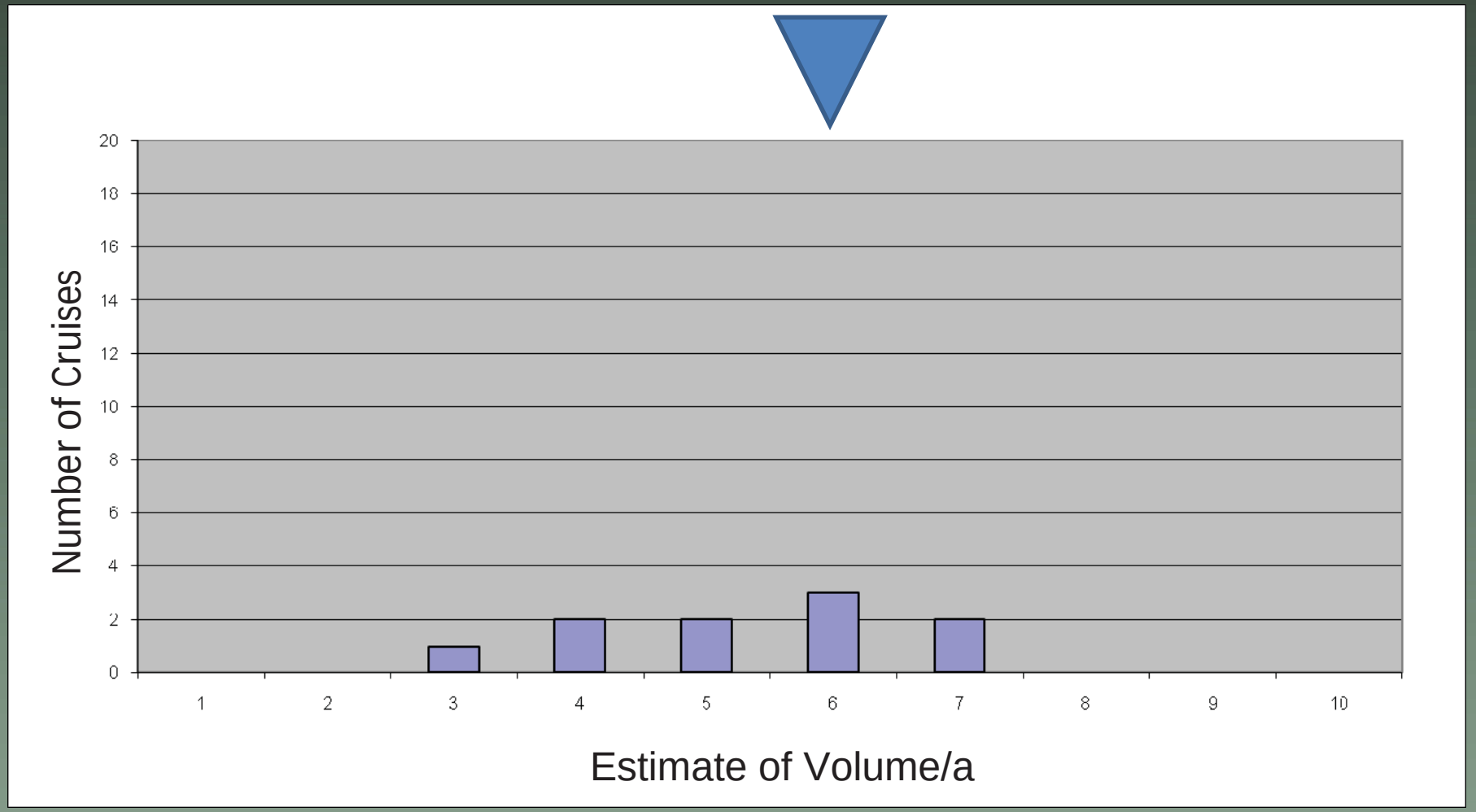
MB&G

TRUE VOLUME = 5.09; CV = 50%; n = 6; CRUISES = 5



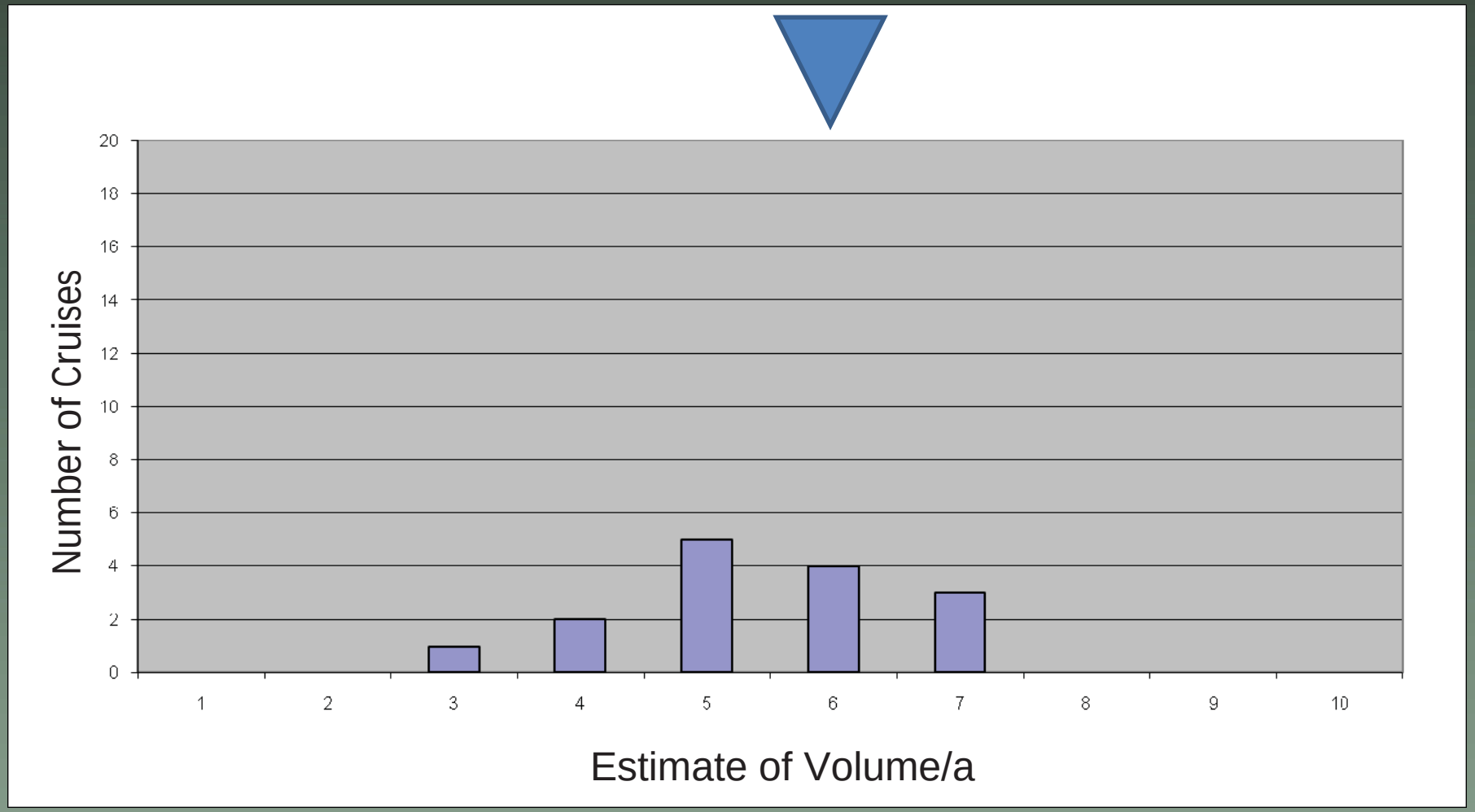
MB&G

TRUE VOLUME = 5.09; CV = 50%; n = 6; CRUISES =10



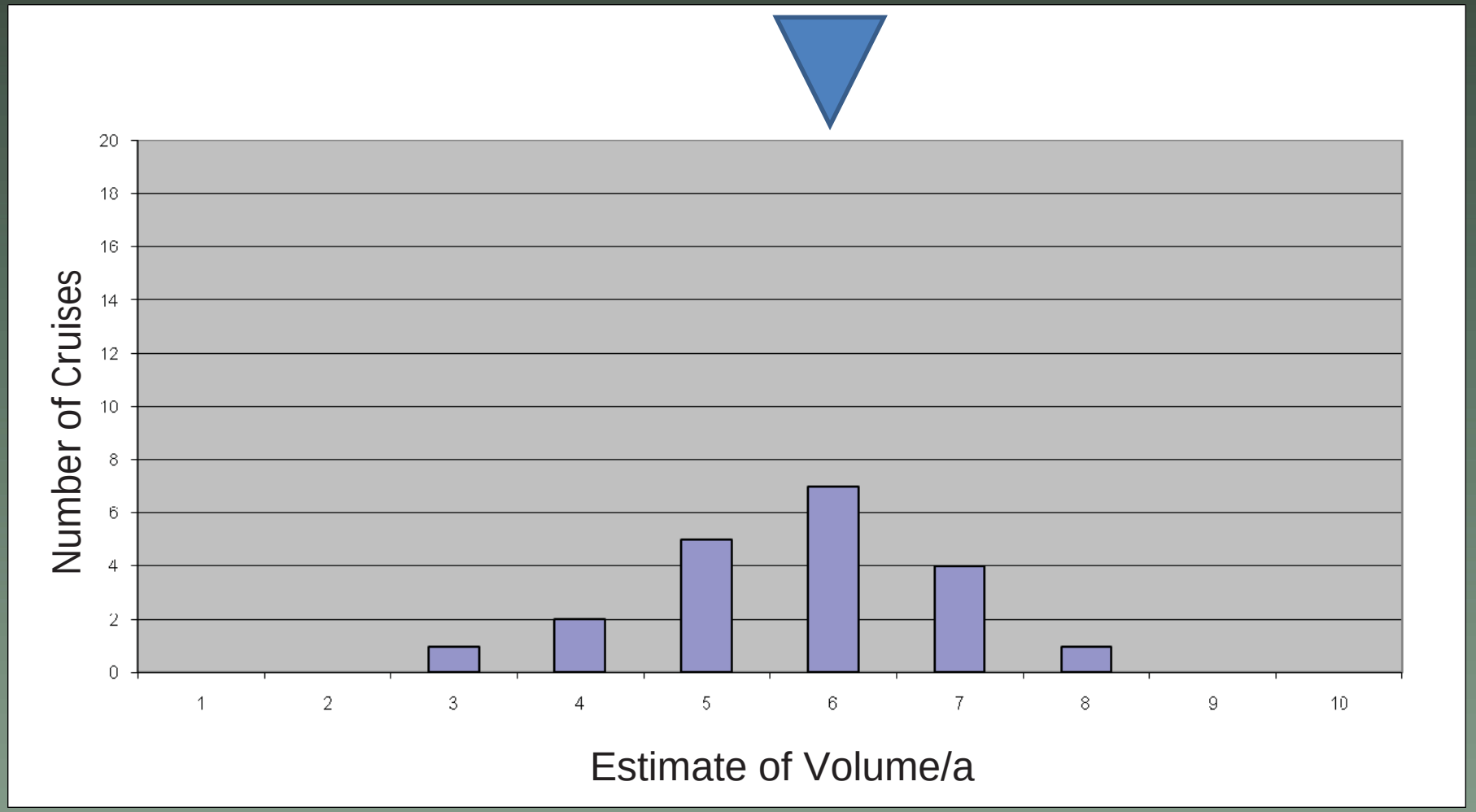
MB&G

TRUE VOLUME = 5.09; CV = 50%; n = 6; CRUISES = 15



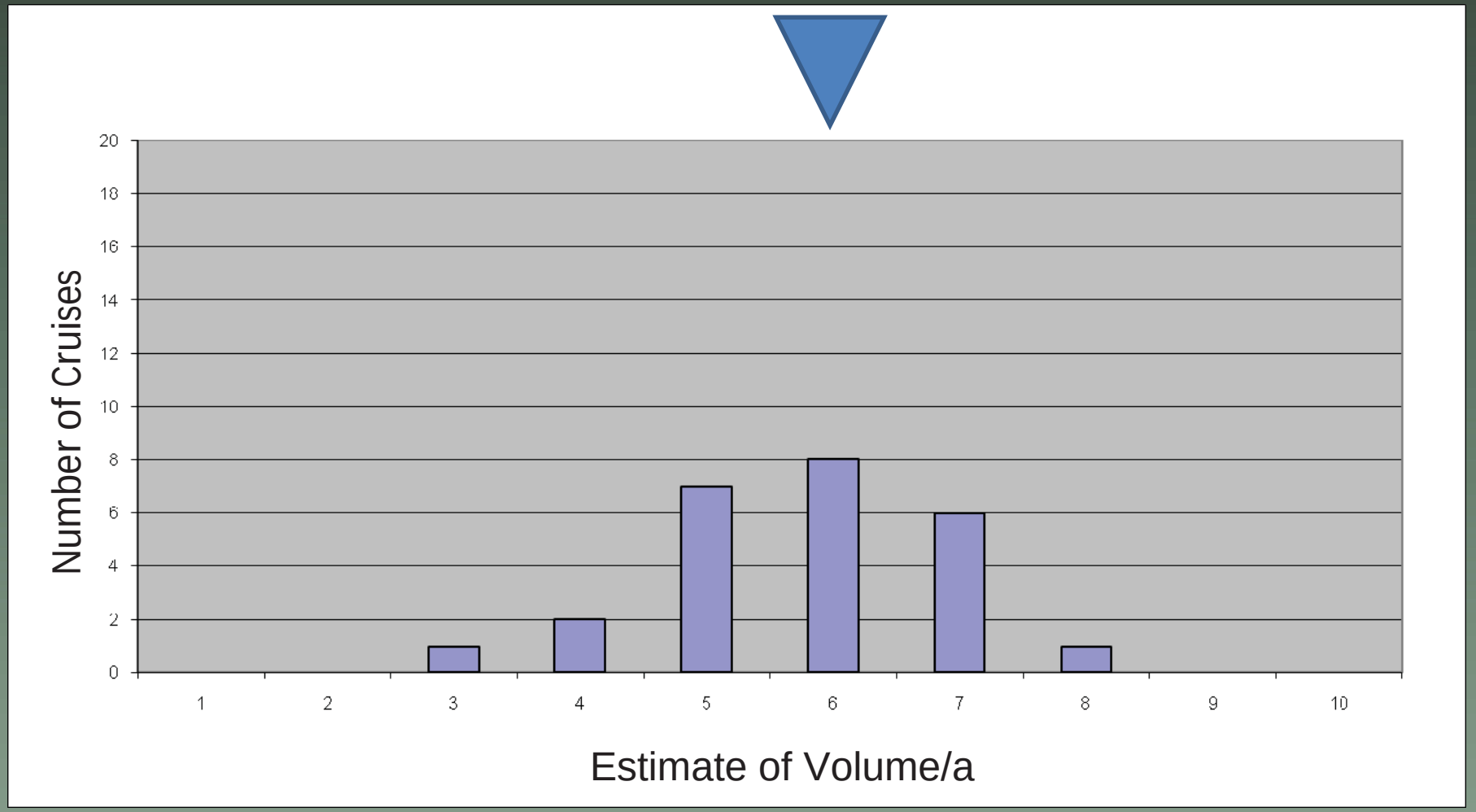
MB&G

TRUE VOLUME = 5.09; CV = 50%; n = 6; CRUISES =20



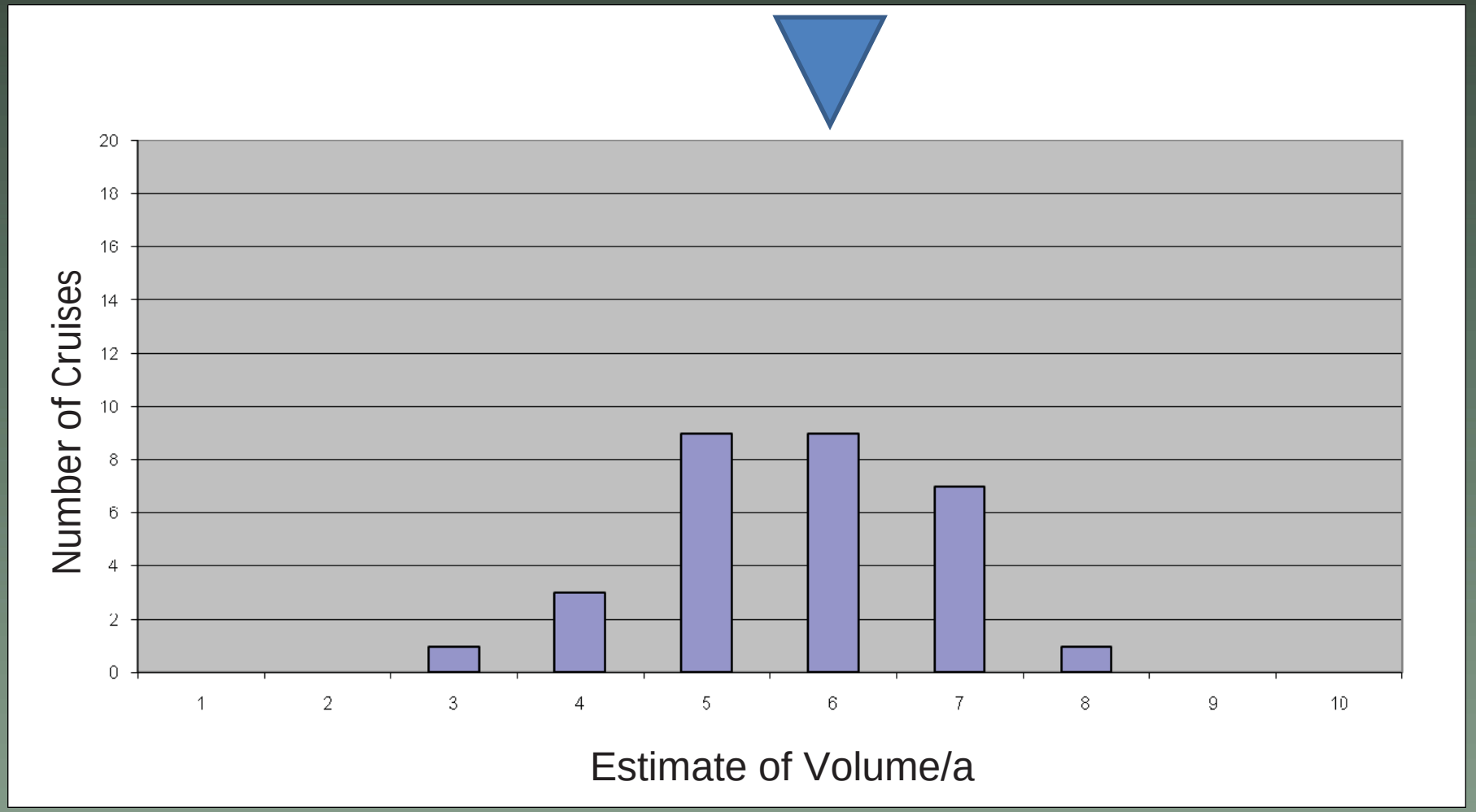
MB&G

TRUE VOLUME = 5.09; CV = 50%; n = 6; CRUISES =25



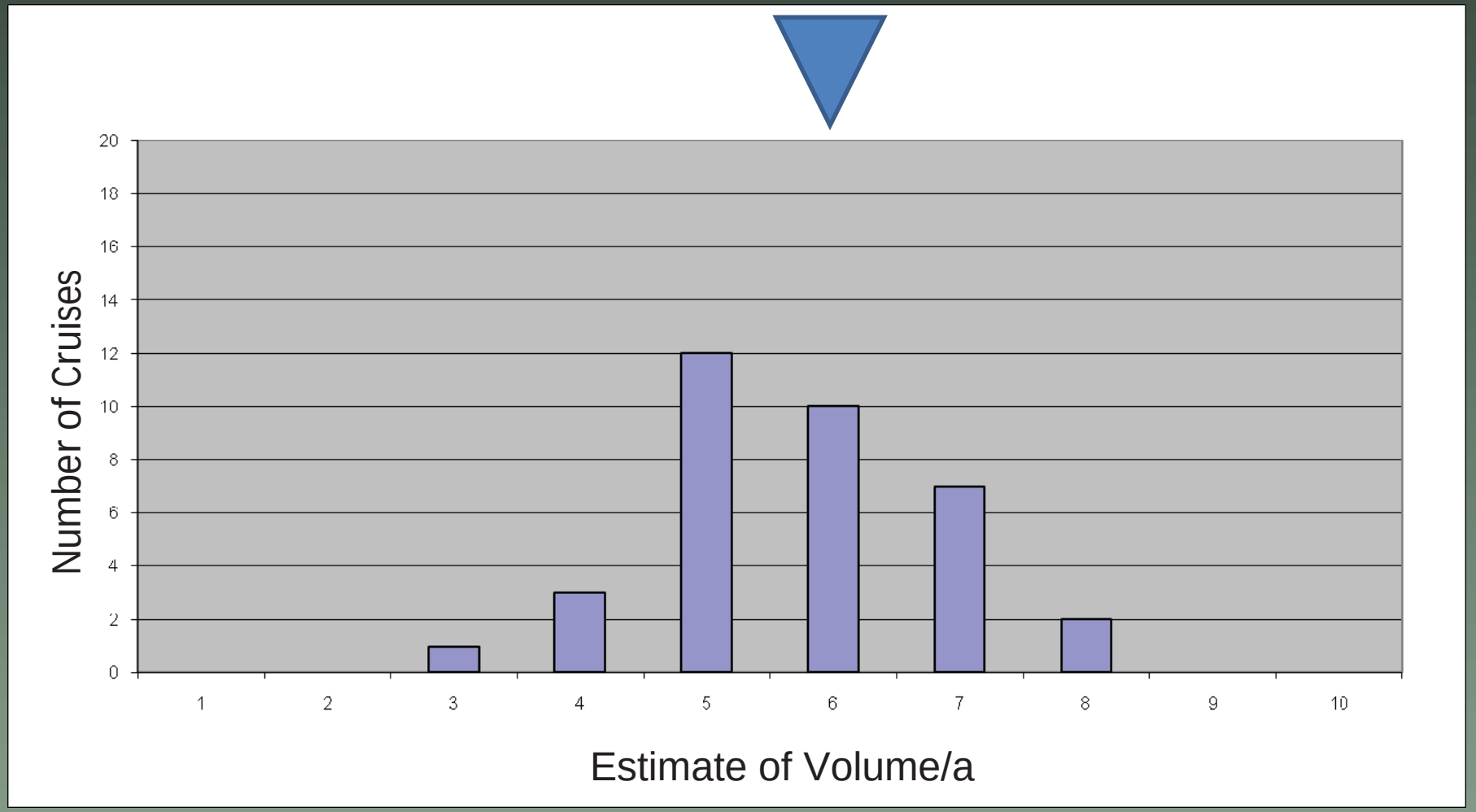
MB&G

TRUE VOLUME = 5.09; CV = 50%; n = 6; CRUISES =30



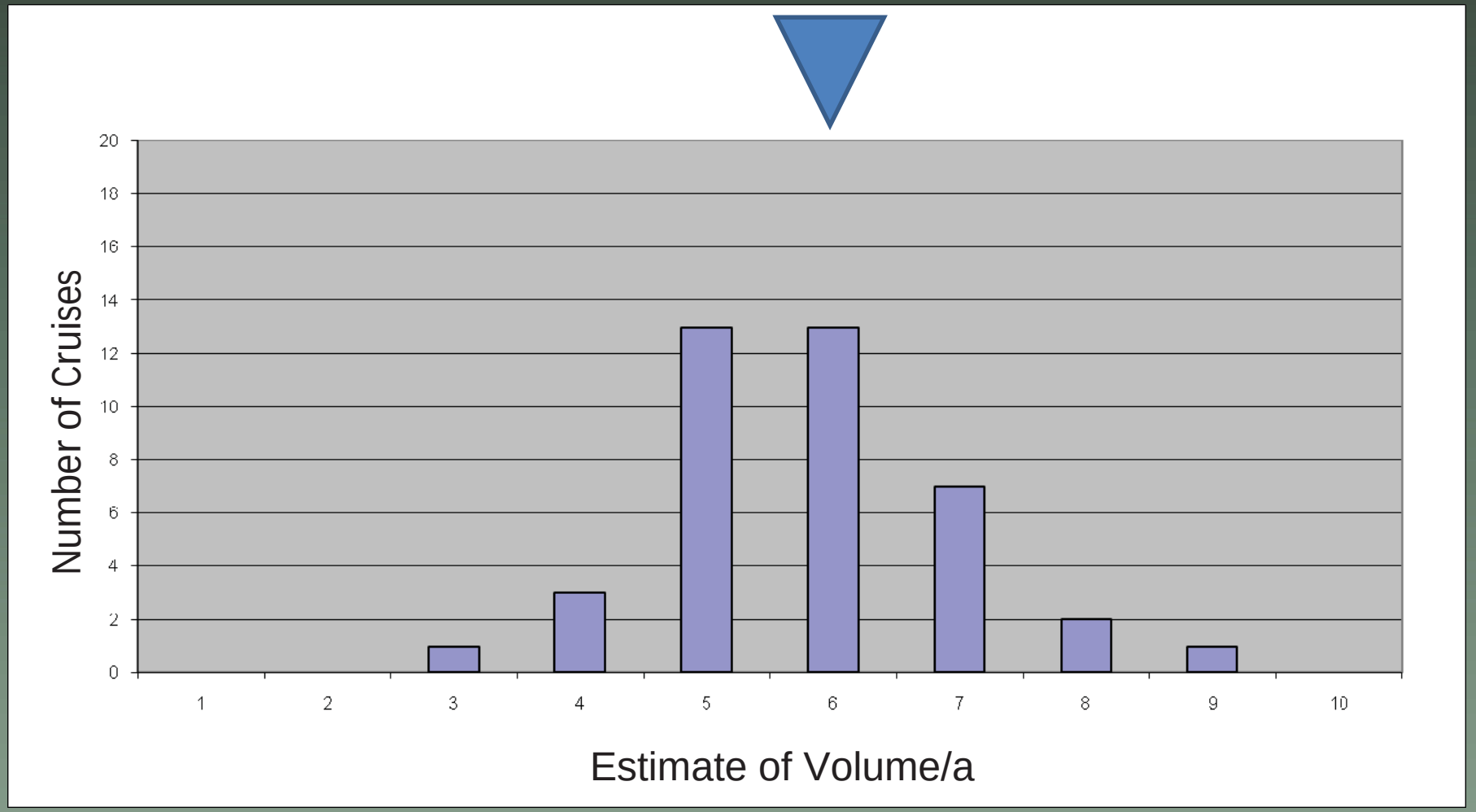
MB&G

TRUE VOLUME = 5.09; CV = 50%; n = 6; CRUISES =35



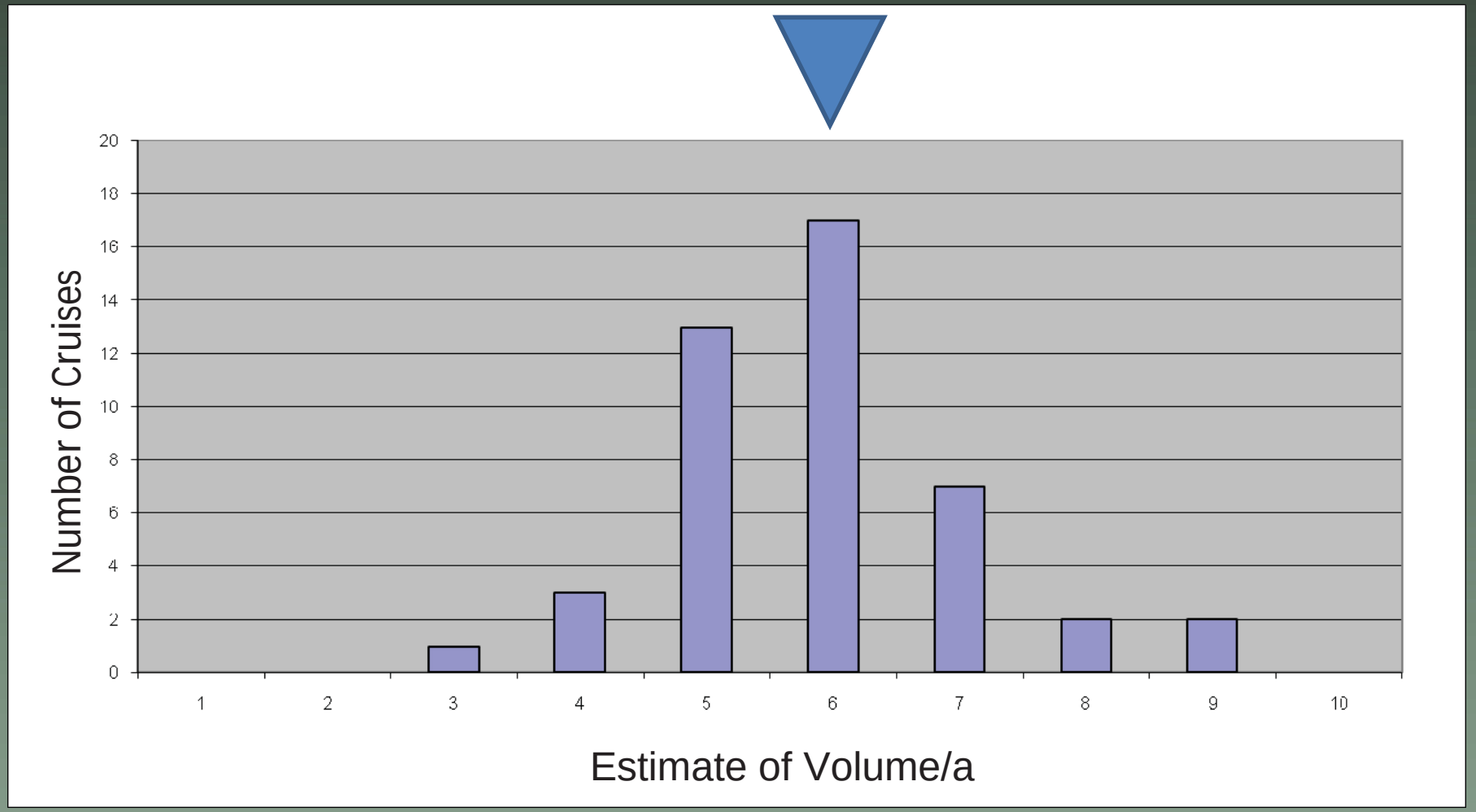
MB&G

TRUE VOLUME = 5.09; CV = 50%; n = 6; CRUISES =40



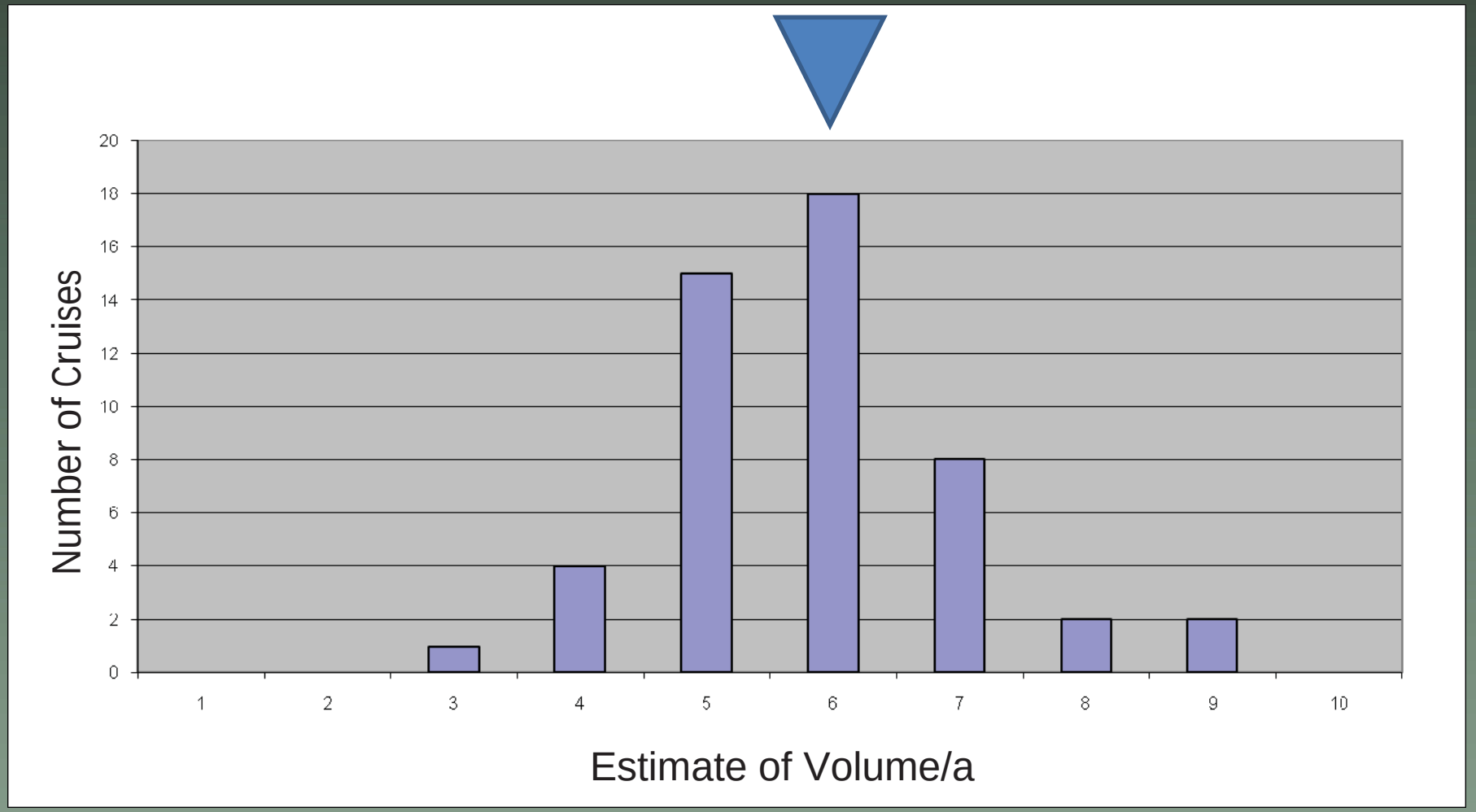
MB&G

TRUE VOLUME = 5.09; CV = 50%; n = 6; CRUISES =45



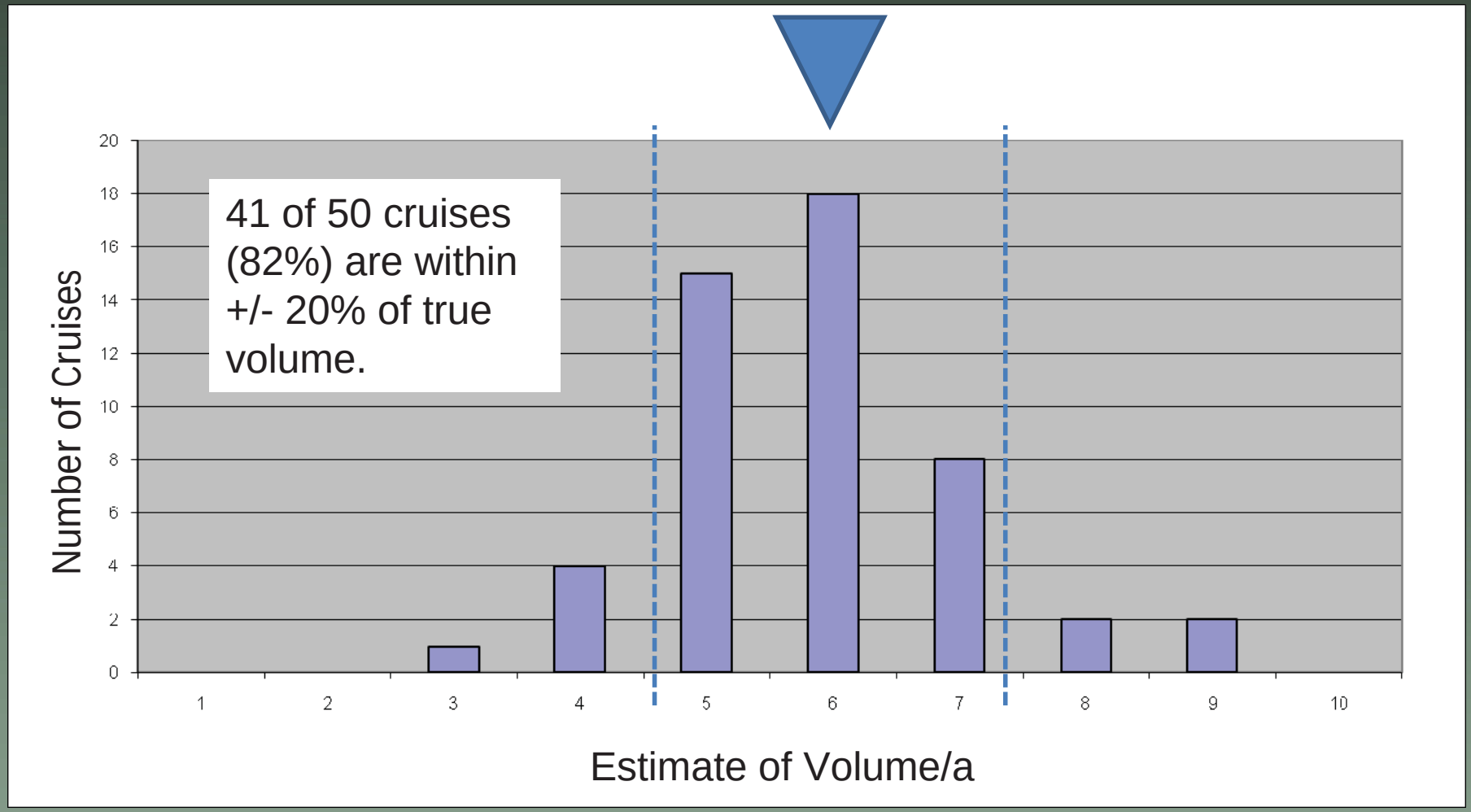
MB&G

TRUE VOLUME = 5.09; CV = 50%; n = 6; CRUISES =50



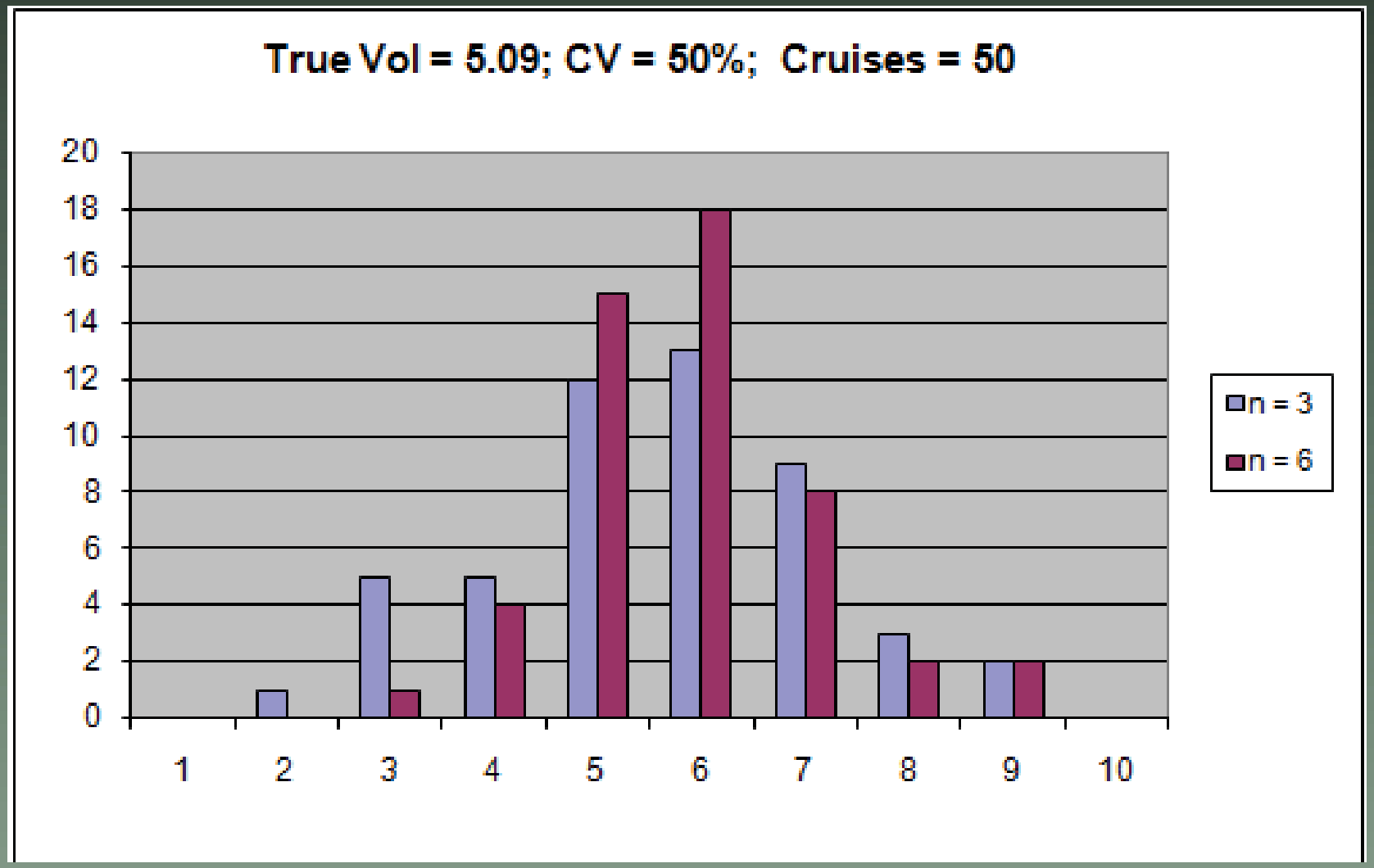
MB&G

TRUE VOLUME = 5.09; CV = 50%; n = 6; CRUISES =50



MB&G

SETTING A CONFIDENCE INTERVAL FOR A STAND-BASED INVENTORY



MB&G

Let's construct a confidence interval around an ownership of 20 stands -

- Suppose our strategy is to cruise 10% of the stands every year; grow the cruised stands to the current point in time with a growth model; and expand to uncruised stands using the average of cruised and grown stands.
- If we've been doing this for the past 10 years, what is the confidence interval around the current inventory estimate?

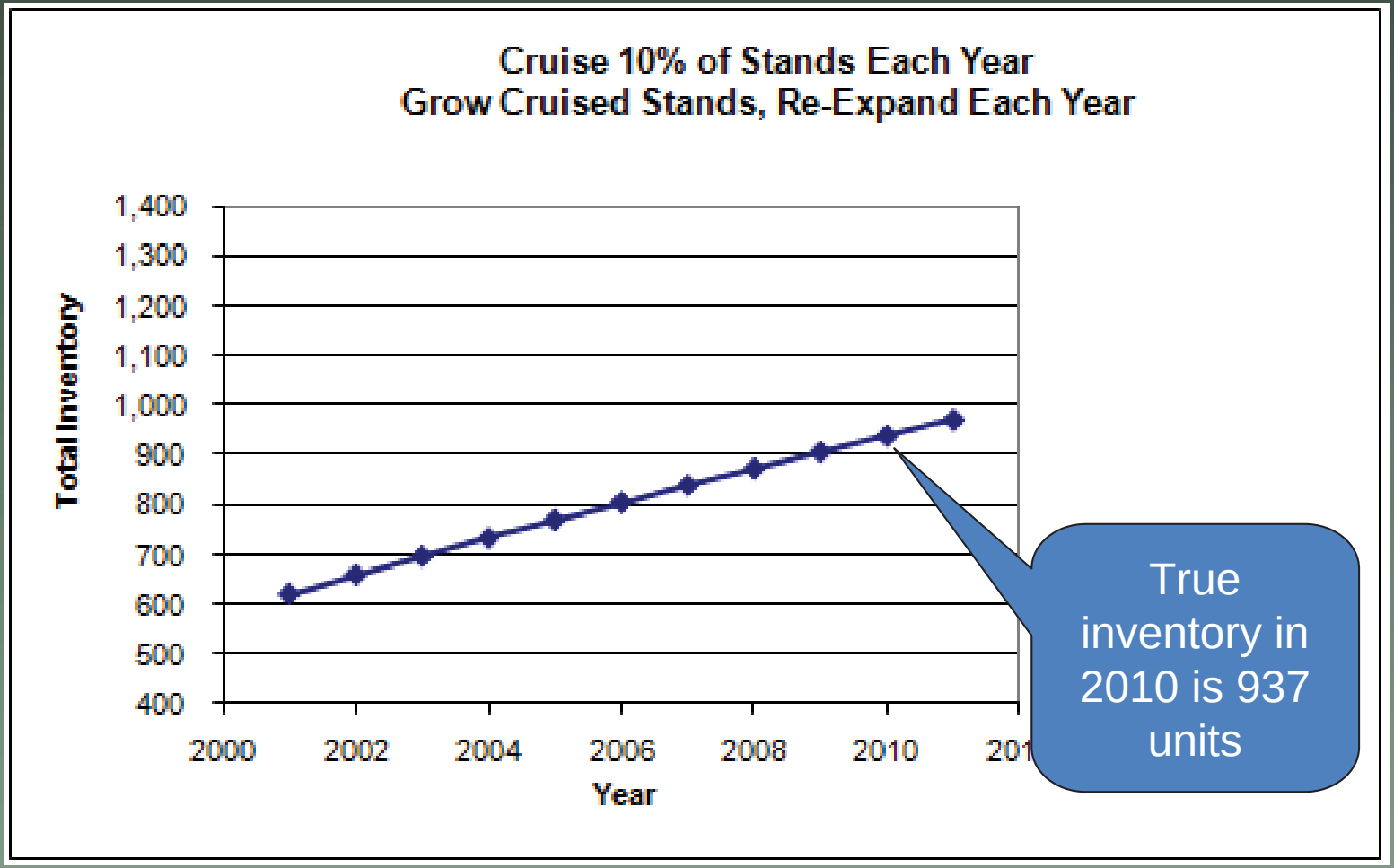
"Set up the population with known attributes" -

THE TRUE INVENTORY (volume per acre, by stand, by year)

Stand	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Acres
A	1,543	1,590	1,636	1,681	1,726	1,769	1,811	1,853	1,894	1,934	1,973	23
B	1,085	1,141	1,196	1,250	1,303	1,355	1,405	1,455	1,504	1,552	1,599	40
C	497	565	631	696	760	823	884	944	1,003	1,061	1,118	56
D	1,031	1,088	1,144	1,199	1,253	1,306	1,358	1,408	1,458	1,507	1,554	26
E	535	602	668	732	795	857	918	977	1,036	1,093	1,149	51
F	1,036	1,093	1,149	1,204	1,258	1,310	1,362	1,413	1,462	1,511	1,559	30
G	676	740	803	865	926	985	1,043	1,100	1,156	1,210	1,264	40
H	1,010	1,068	1,124	1,179	1,234	1,287	1,339	1,390	1,440	1,489	1,537	25
I	761	824	885	945	1,004	1,062	1,118	1,174	1,228	1,281	1,334	10
J	855	916	975	1,034	1,091	1,147	1,202	1,255	1,308	1,360	1,410	43
K	516	583	650	714	778	840	901	961	1,020	1,077	1,133	44
L	878	938	997	1,055	1,112	1,167	1,222	1,275	1,328	1,379	1,429	36
M	1,418	1,468	1,516	1,564	1,610	1,656	1,701	1,745	1,788	1,830	1,871	22
N	1,191	1,245	1,298	1,350	1,401	1,451	1,499	1,547	1,594	1,640	1,685	12
O	1,369	1,419	1,469	1,517	1,565	1,612	1,657	1,702	1,746	1,789	1,831	48
P	734	797	859	920	979	1,037	1,094	1,150	1,205	1,259	1,312	15
Q	1,181	1,235	1,288	1,340	1,391	1,442	1,491	1,539	1,586	1,632	1,677	33
R	1,105	1,161	1,215	1,269	1,321	1,373	1,423	1,473	1,521	1,568	1,615	50
S	1,190	1,244	1,297	1,349	1,400	1,450	1,499	1,546	1,593	1,639	1,684	15
T	1,362	1,413	1,462	1,511	1,559	1,605	1,651	1,696	1,740	1,783	1,825	31

- In the simulation, if our inventory strategy is good, we will expect to see our estimates close to these true values

"Set up the population with known attributes" –



"Apply our estimation methodology to the population" -

INVENTORY UPDATE STRATEGY				1=Cruise	2=Grow	3=Expand				
Stand	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
A	3	3	3	1	2	2	2	2	2	2	2
B	3	3	3	3	3	1	2	2	2	2	2
C	1	2	2	2	2	2	2	2	2	2	1
D	3	1	2	2	2	2	2	2	2	2	2
E	1	2	2	2	2	2	2	2	2	2	1
F	3	3	3	3	1	2	2	2	2	2	2
G	3	3	3	1	2	2	2	2	2	2	2
H	3	3	3	3	3	3	1	2	2	2	2
I	3	3	3	3	3	3	3	1	2	2	2
J	3	3	3	3	3	3	3	1	2	2	2
K	3	3	3	3	3	3	1	2	2	2	2
L	3	3	3	3	3	3	3	3	3	1	2
M	3	3	1	2	2	2	2	2	2	2	2
N	3	3	3	3	3	3	3	3	3	1	2
O	3	3	3	3	3	3	3	3	1	2	2
P	3	1	2	2	2	2	2	2	2	2	2
Q	3	3	1	2	2	2	2	2	2	2	2
R	3	3	3	3	3	3	3	3	1	2	2
S	3	3	3	3	1	2	2	2	2	2	2
T	3	3	3	3	3	1	2	2	2	2	2

"Apply our estimation methodology to the population" -

- Suppose our cruise policy to install enough plots to achieve an allowable error, at the stand level, of +/- 20% at a confidence level of 90%.
- If the stand is too small to install the target number of plots, install 1 plot for every 2 acres

0.5	CV for volume within stand
0.2	AE for volume within stand
0.9	Conf. Level
1.7	T-value
18.0625	Target Plots per stand
18	Integer plots
2	Min acres per plot
$ 30.00	Cost per plot

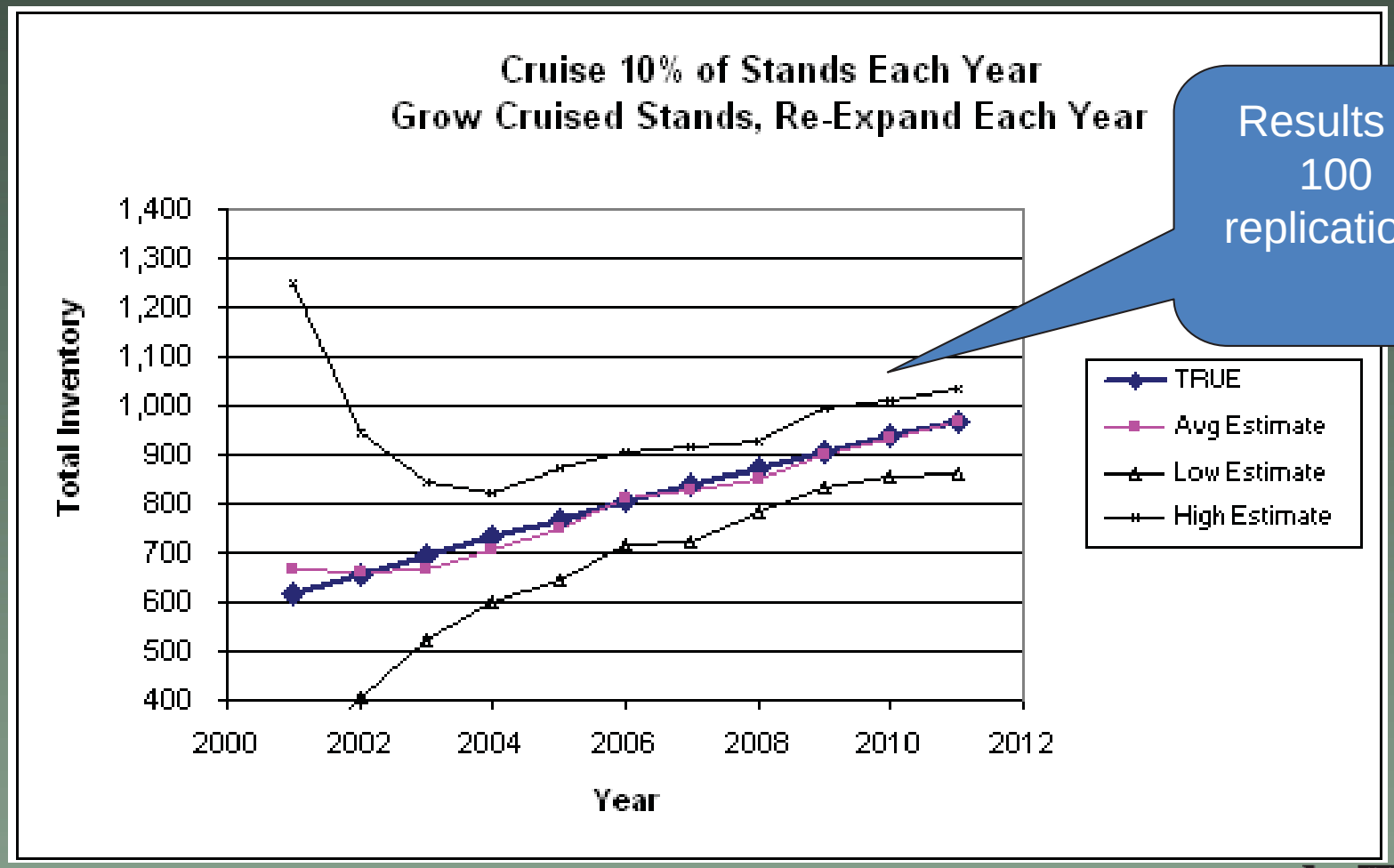
Stand	Acres	Actual Plots
A	23	11
B	40	18
C	56	18
D	26	13
E	51	18
F	30	15
G	40	18
H	25	12

SETTING A CONFIDENCE INTERVAL FOR A STAND-BASED INVENTORY

"Apply our estimation methodology to the population" -

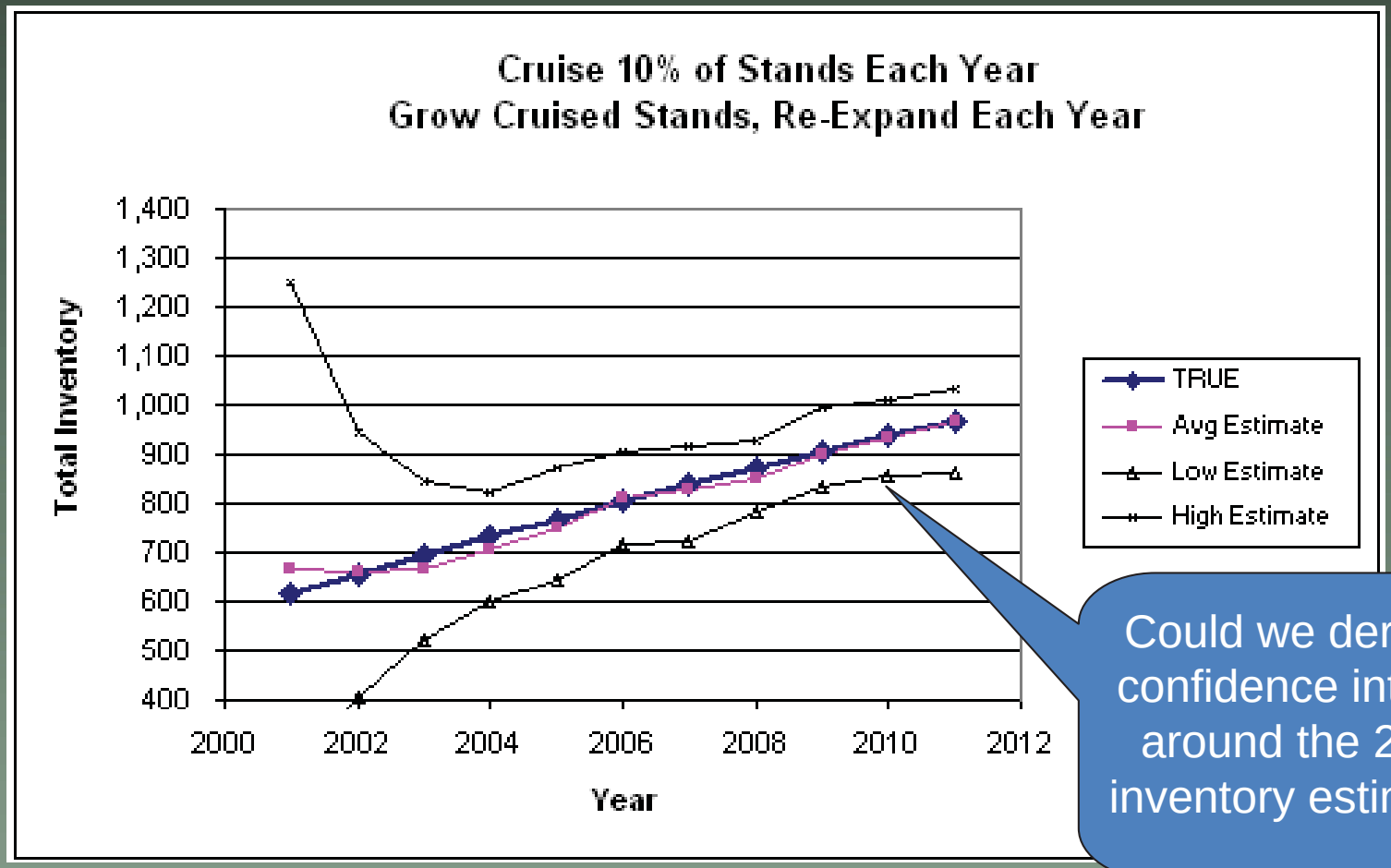
- Suppose our growth model is perfect;
  - the input to the growth model is the cruise result for the stand, and if the cruise estimate matches the true value of the stand, the growth model will predict the true value of the stand in the next year.
  - If the cruise result for the stand is different from the true value for the stand, the perfect growth model will not predict the true value of the stand in the next year.
- An expanded estimate uses the average of the current cruised stands and grown results of the previously cruised stands

"Apply the estimation method many times, and keep track of the range of estimates" -



SETTING A CONFIDENCE INTERVAL FOR A STAND-BASED INVENTORY

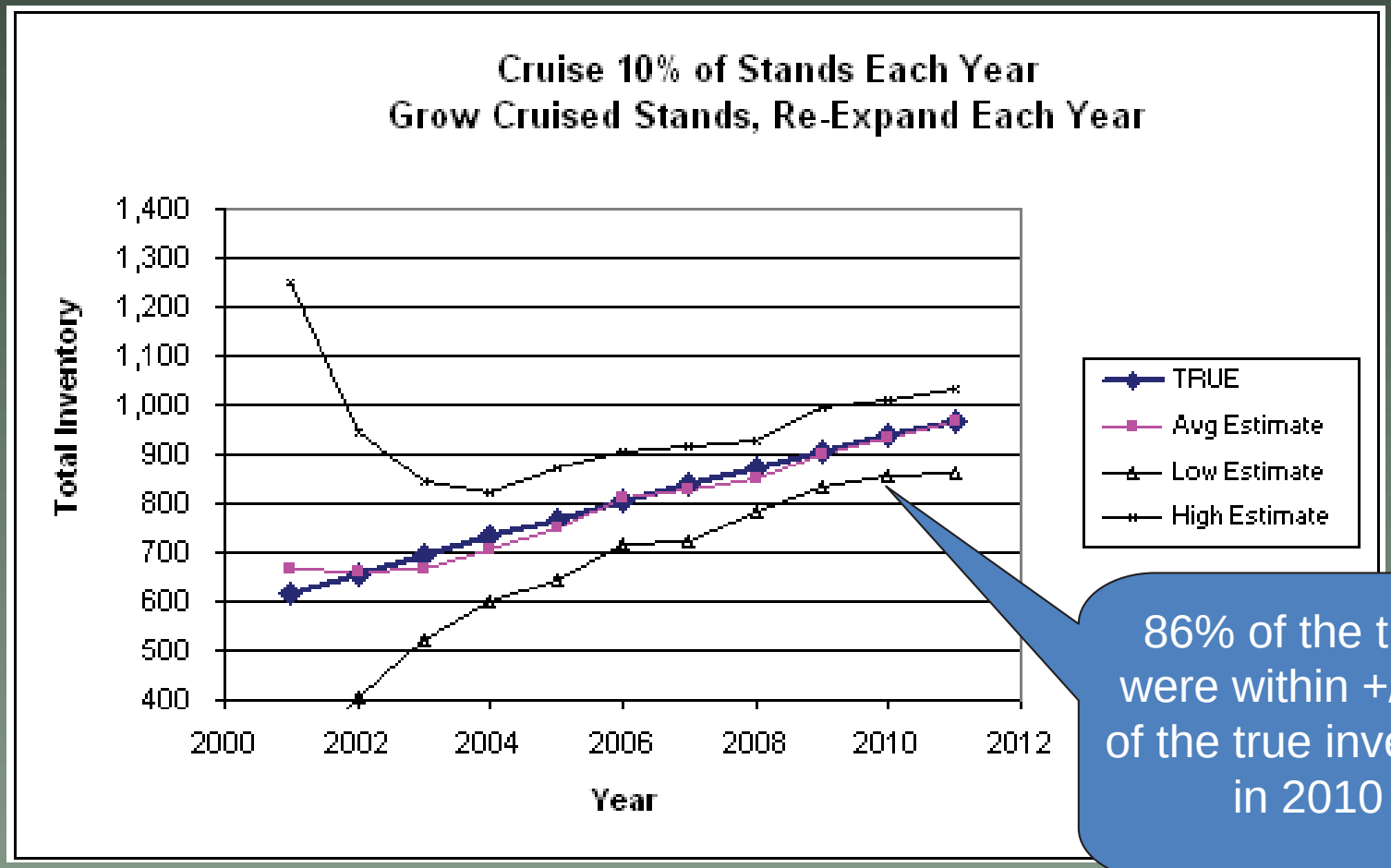
"Apply the estimation method many times, and keep track of the range of estimates" -



Could we derive a confidence interval around the 2010 inventory estimate?

MB&G

"Apply the estimation method many times, and keep track of the range of estimates" -



SETTING THE CONFIDENCE INTERVAL AROUND THE TOTAL INVENTORY ESTIMATE FOR A STAND-BASED INVENTORY

Steve Fairweather
Mason, Bruce & Girard, Inc.
Portland, OR

sfairweather@masonbruce.com

Timber Measurements Society, 2011

MB&G