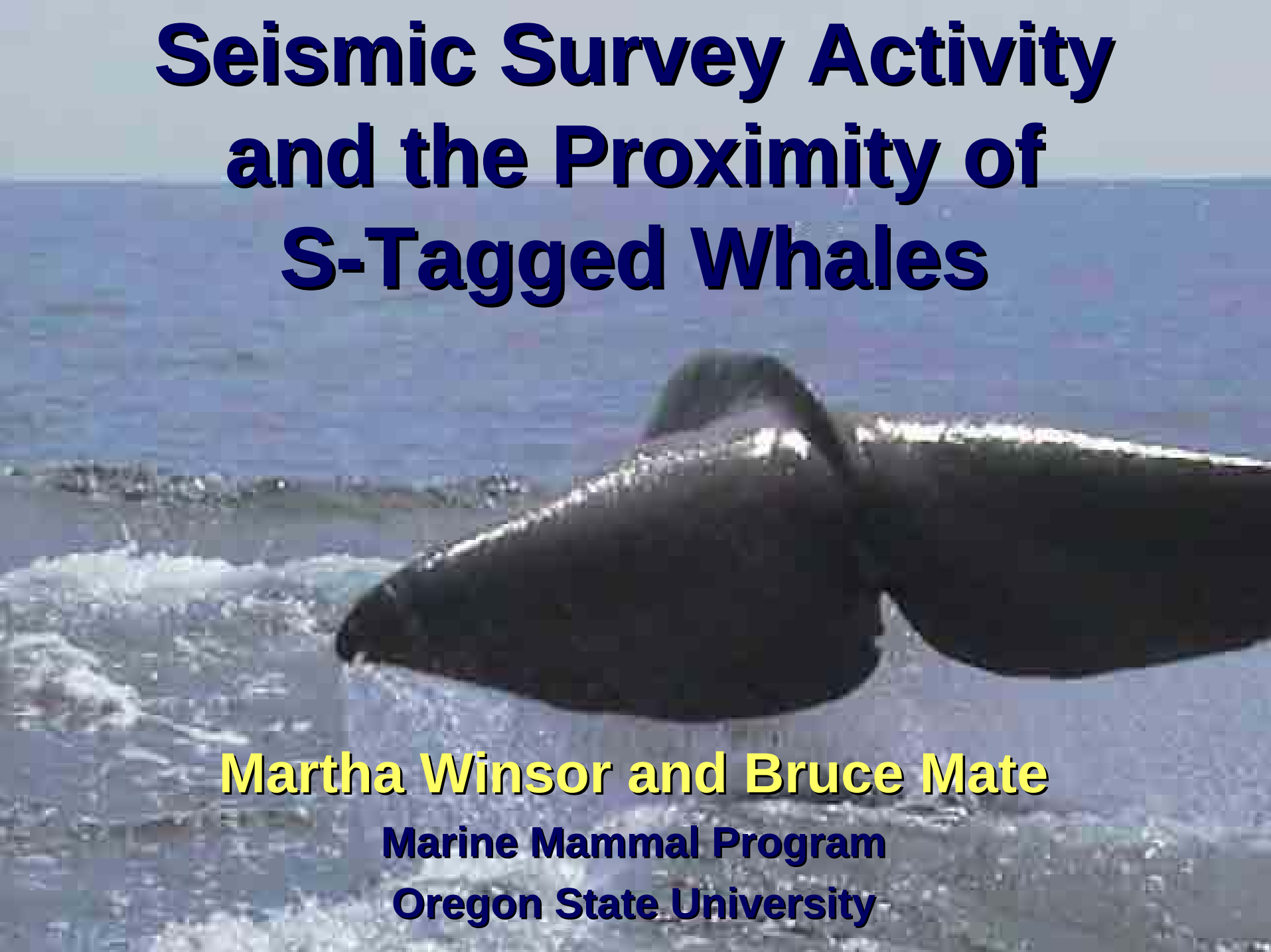
Seismic Survey Activity and the Proximity of S-Tagged Whales



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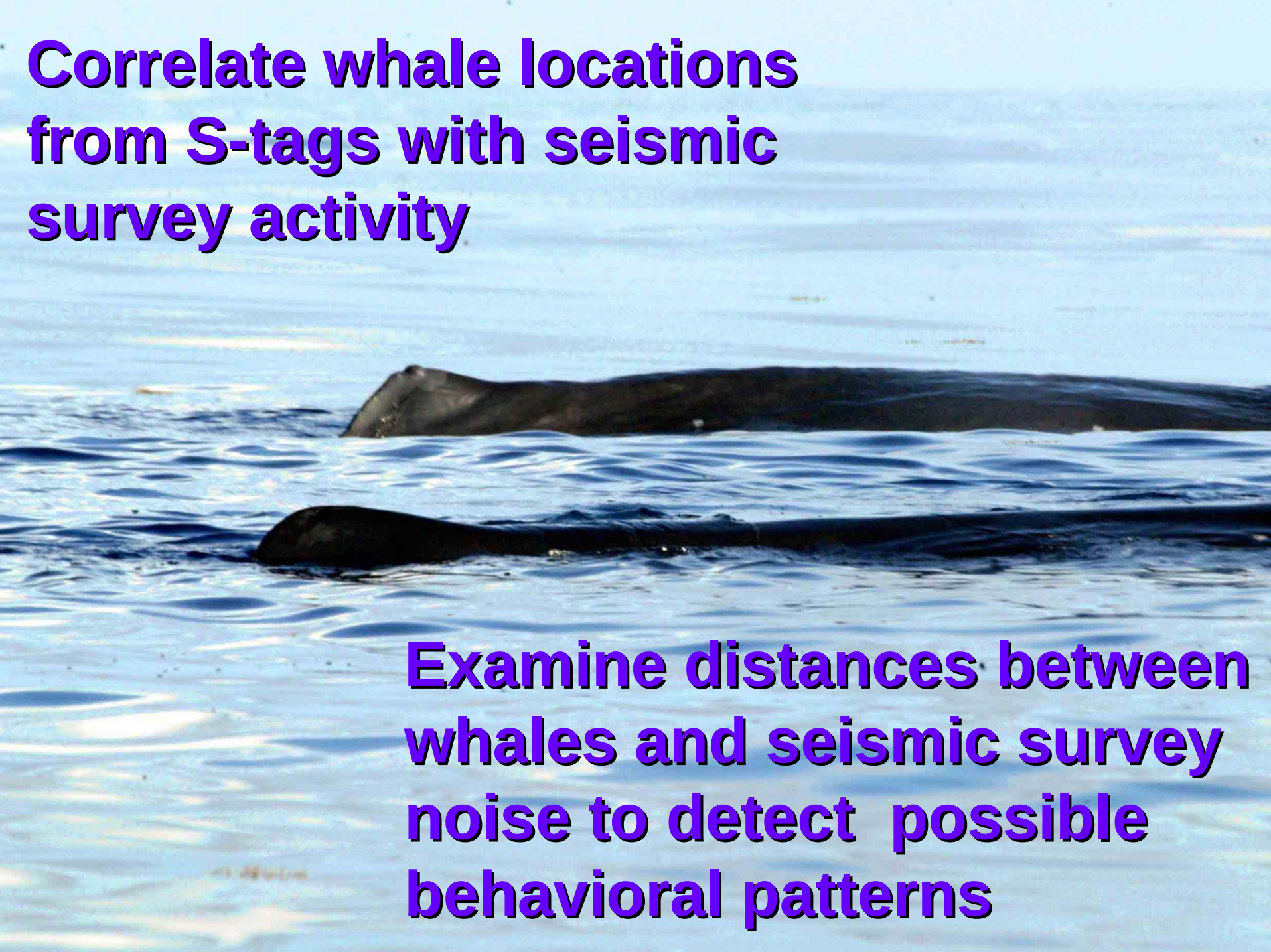
Oregon State University

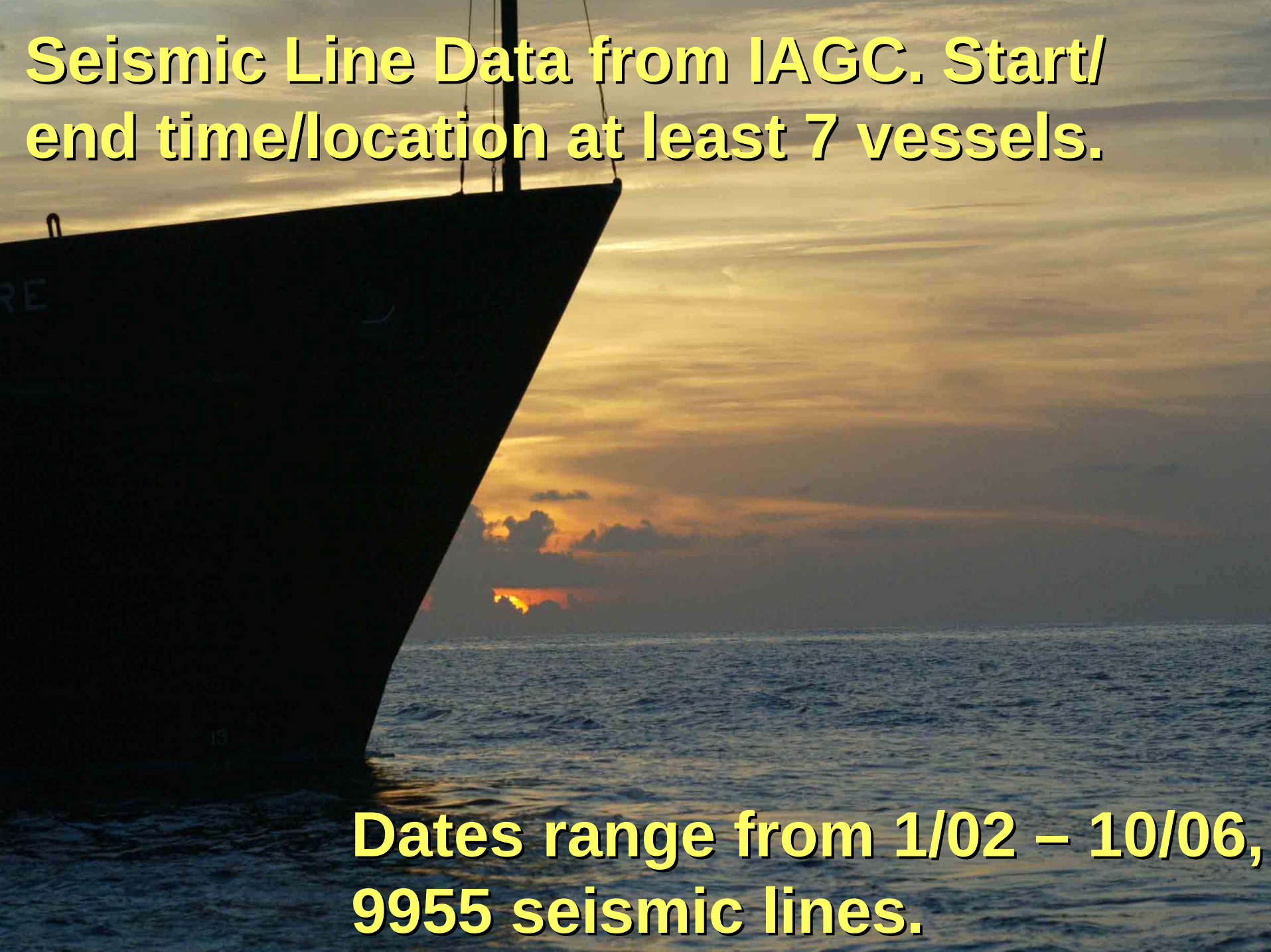
Sperm whales are highly acoustically-oriented. There are concerns about possible changes in behavior when subjected to airgun noise from seismic vessels.

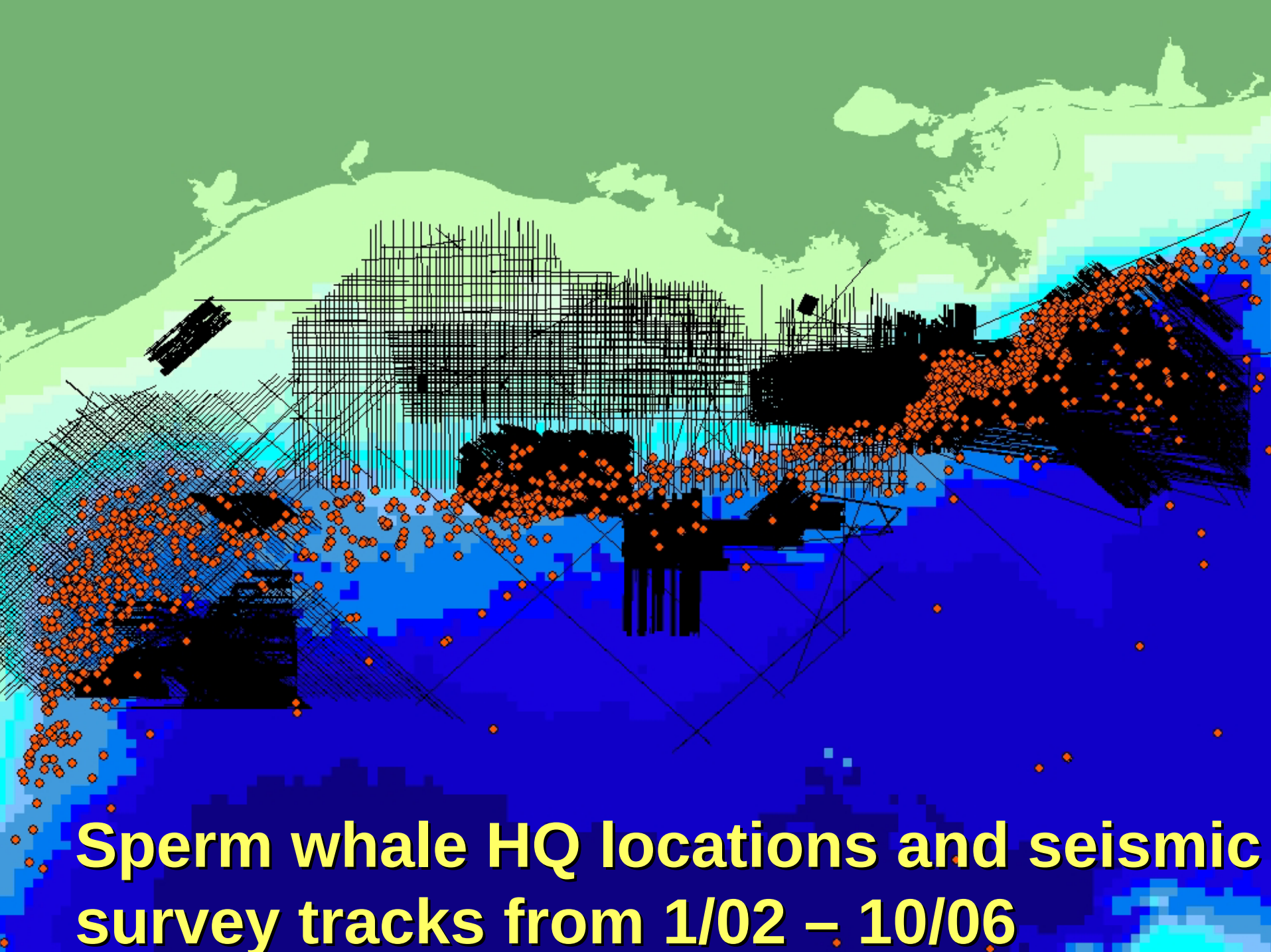
They frequently occur in areas extensively surveyed by seismic vessels.


Correlate whale locations from S-tags with seismic survey activity
Examine distances between whales and seismic survey noise to detect possible behavioral patterns

S-tags deployed during summers 2002–2005 on sperm whales in the GOM as part of SWSS

53 S-tags provided
1559 HQ locations


Seismic Line Data from IAGC. Start/ end time/location at least 7 vessels.
Dates range from 1/02 – 10/06, 9955 seismic lines.



Sperm whale HQ locations and seismic survey tracks from 1/02 – 10/06

S-tags study designed to describe long-term (months) movements and distributions.

The proximity of seismic vessel activity provided opportunity to explore distances between animals and airgun noise.

S-Tag to Central Shot Point Distance

- The central shot point locations for the same time as whale locations were computed by interpolating between the start and end line locations assuming a constant speed and heading of the vessel.
- The distance/direction between the interpolated shot point and whale location were calculated.
- Only distances less than 100 km were used.

34 Whales Had (1-40 N=334) Locations within 100 km of Active Airguns

minimum 5.01 km

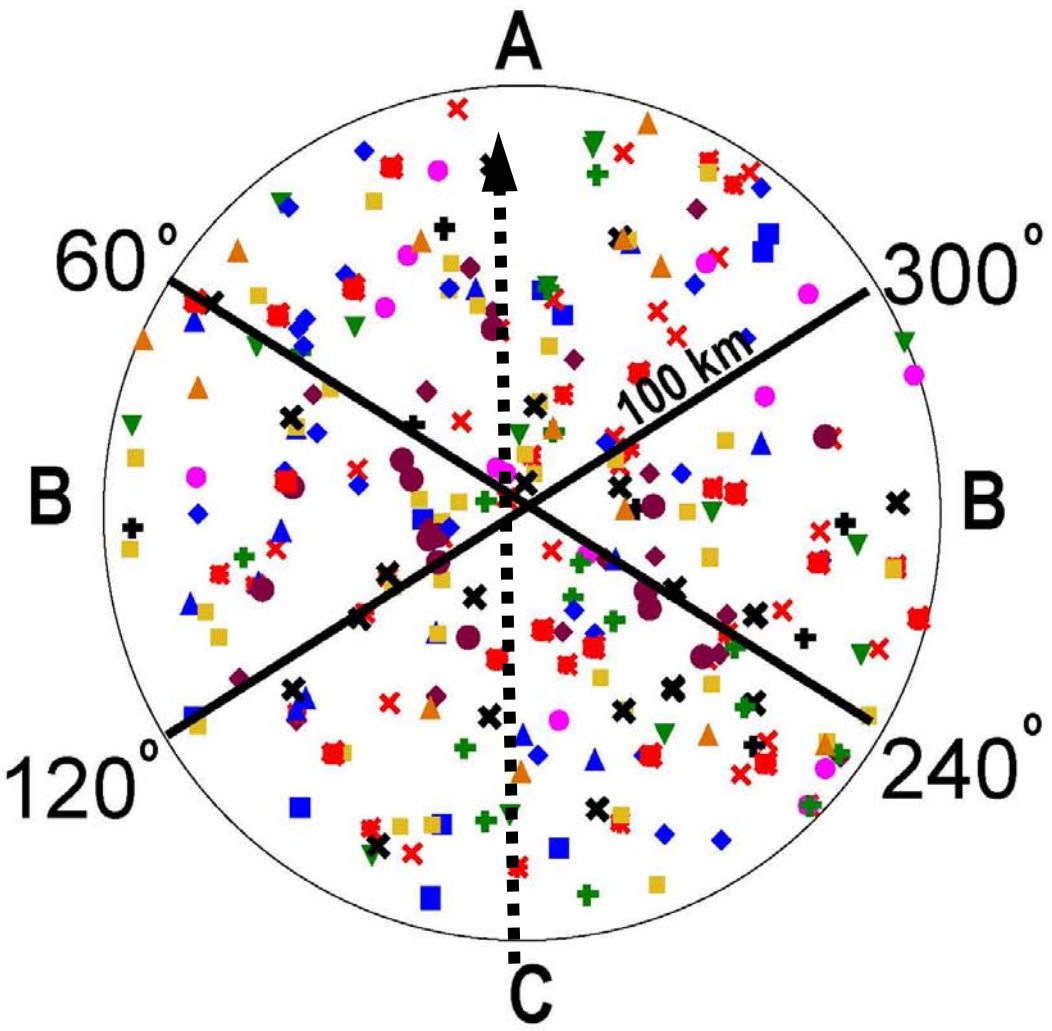
average minimum 39.9 km (S.D.=27.1)

Individuals with >7 locations (15):

average minimum 16.5 km (S.D.=7.3)

ranged from 5.01 – 27.4 km

Distance from shotpoint (radius = 100km) and bearing relative to ship's heading

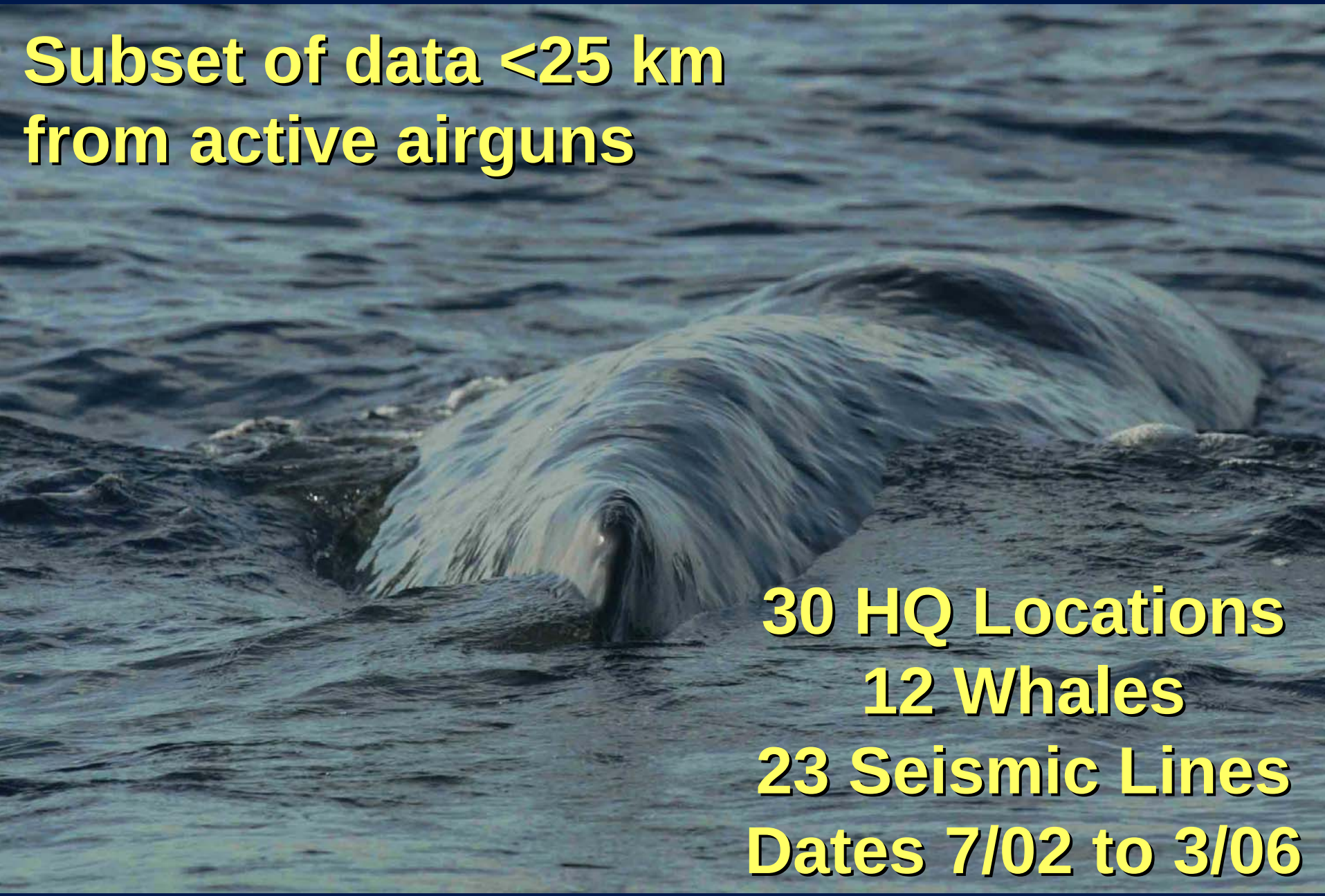


S-tag
- 2505647
- 2505649
- 2505650
- 2505654
- 2505655
- 2505669
- 2505670
- 2505685
- 2505701
- 2505709
- 2505710
- 2505726
- 2800828
- 2801385
- 2805710

The relative bearing of the whale location to the vessel track was categorized into 3 classes.

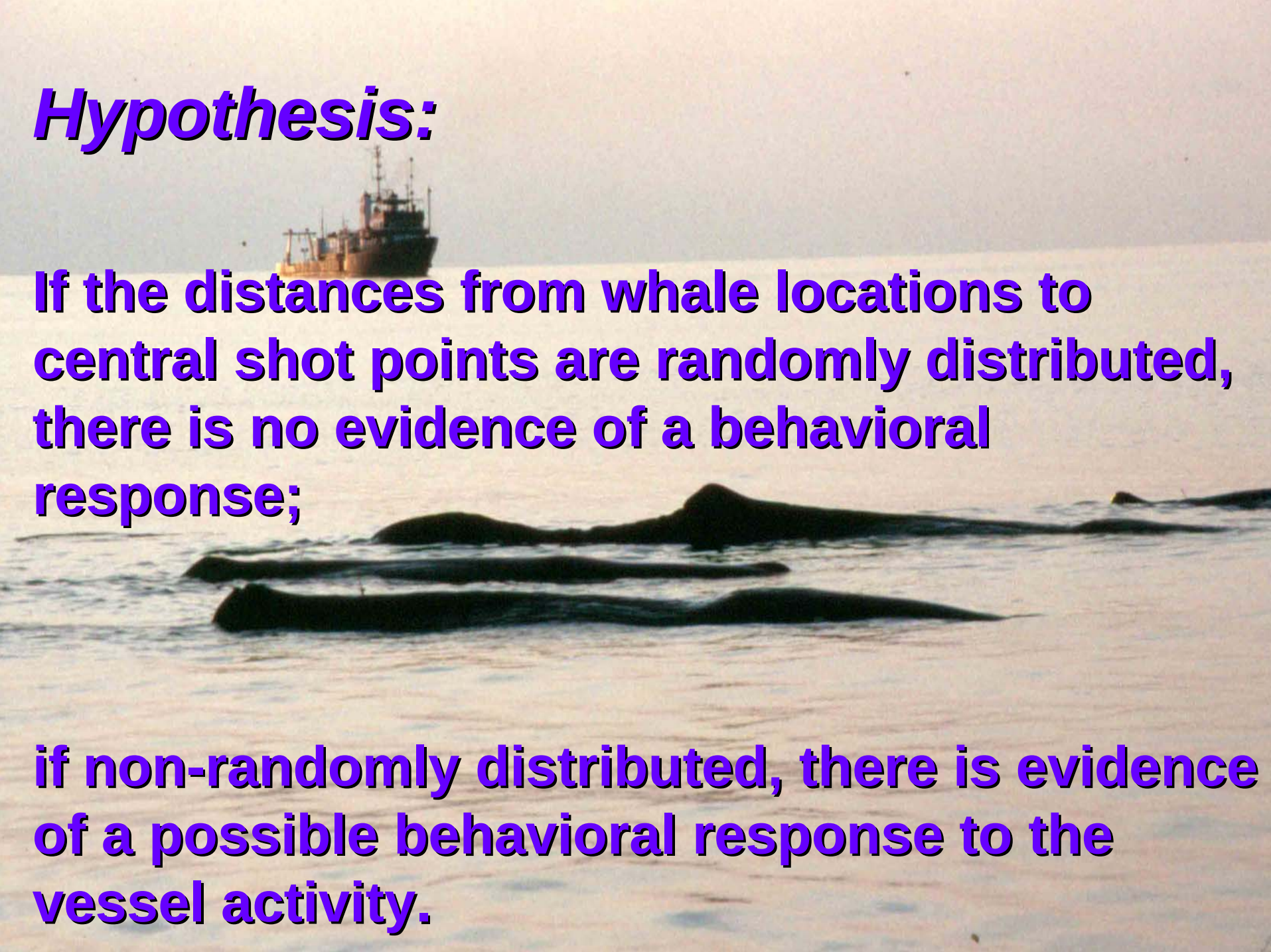
No relationship between distance and bearing class or significant difference of bearing class

GLM; $p = 0.32$



Subset of data <25 km from active airguns

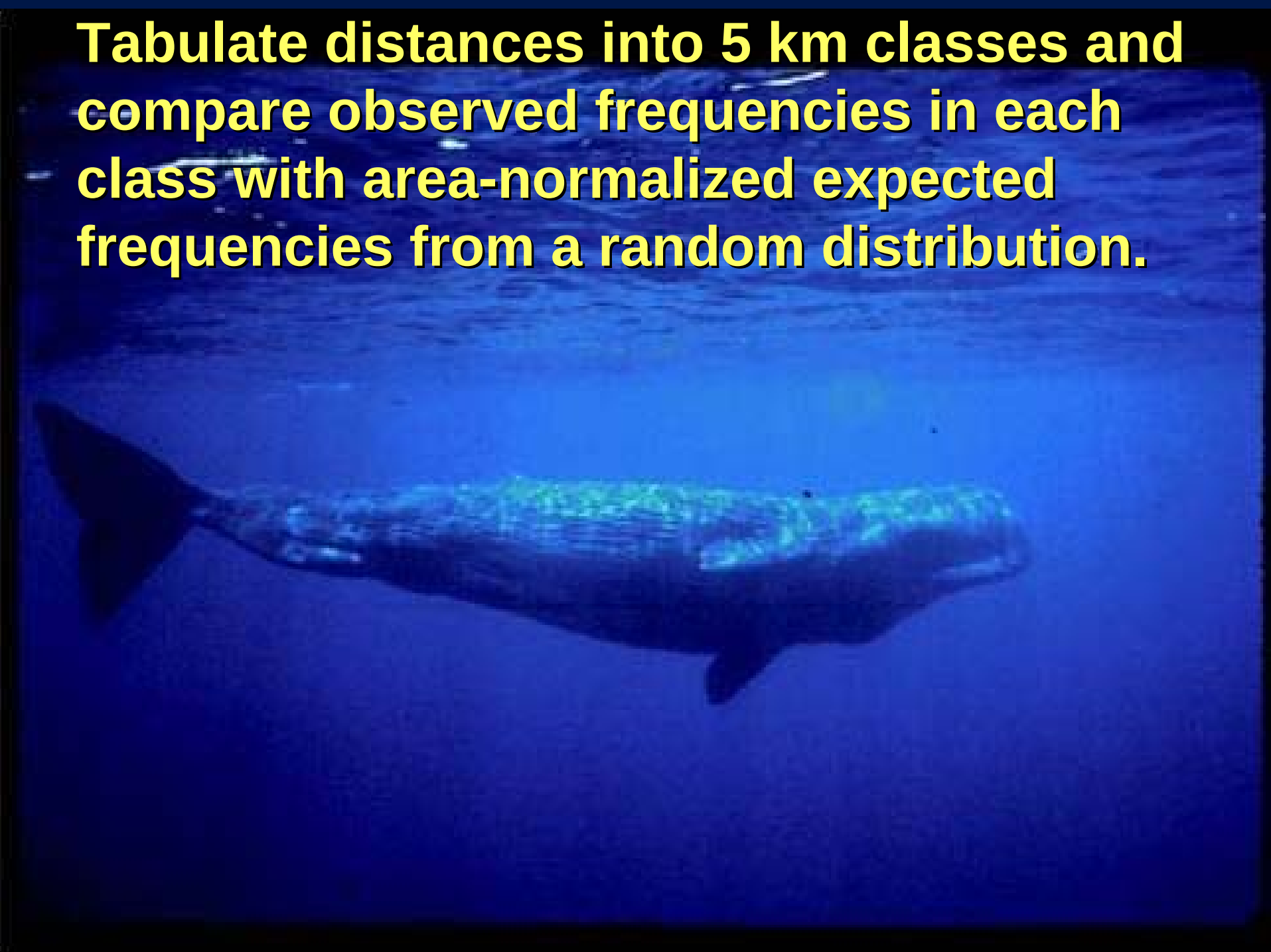
30 HQ Locations
12 Whales
23 Seismic Lines
Dates 7/02 to 3/06



Hypothesis:

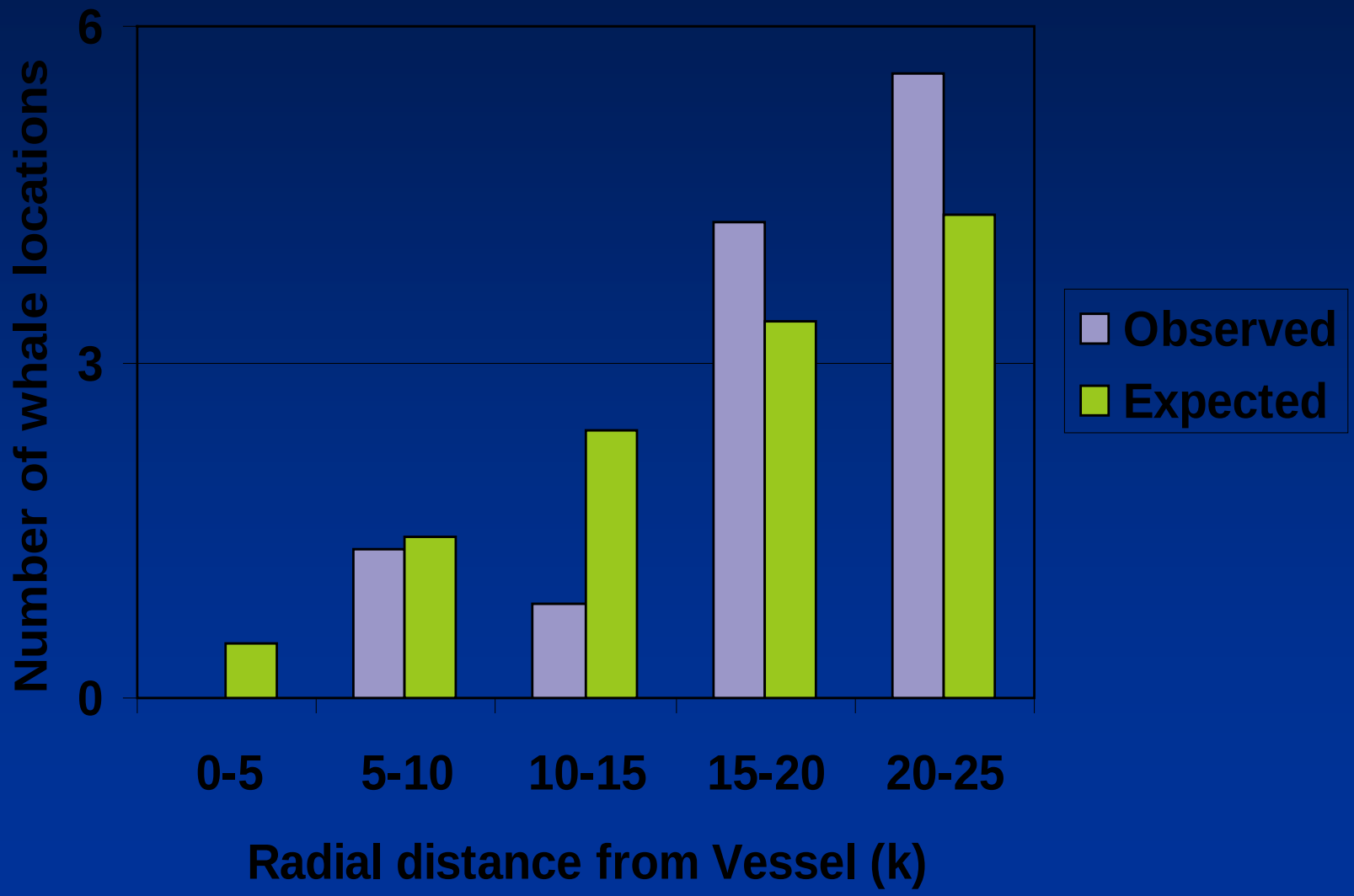
If the distances from whale locations to central shot points are randomly distributed, there is no evidence of a behavioral response;

if non-randomly distributed, there is evidence of a possible behavioral response to the vessel activity.

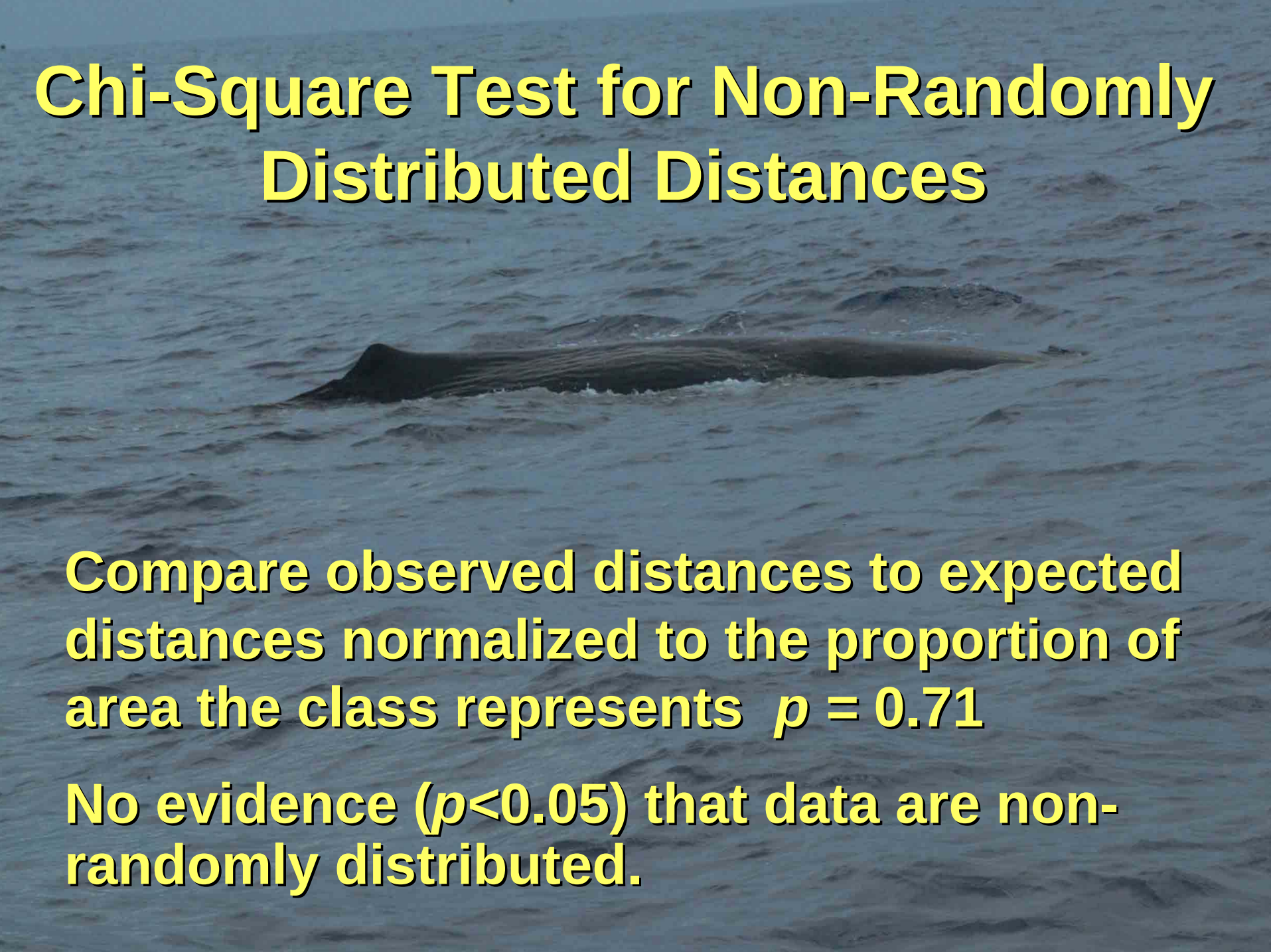


Tabulate distances into 5 km classes and compare observed frequencies in each class with area-normalized expected frequencies from a random distribution.

Distance (k) from Whale to Central Shotpoint in 5k Classes

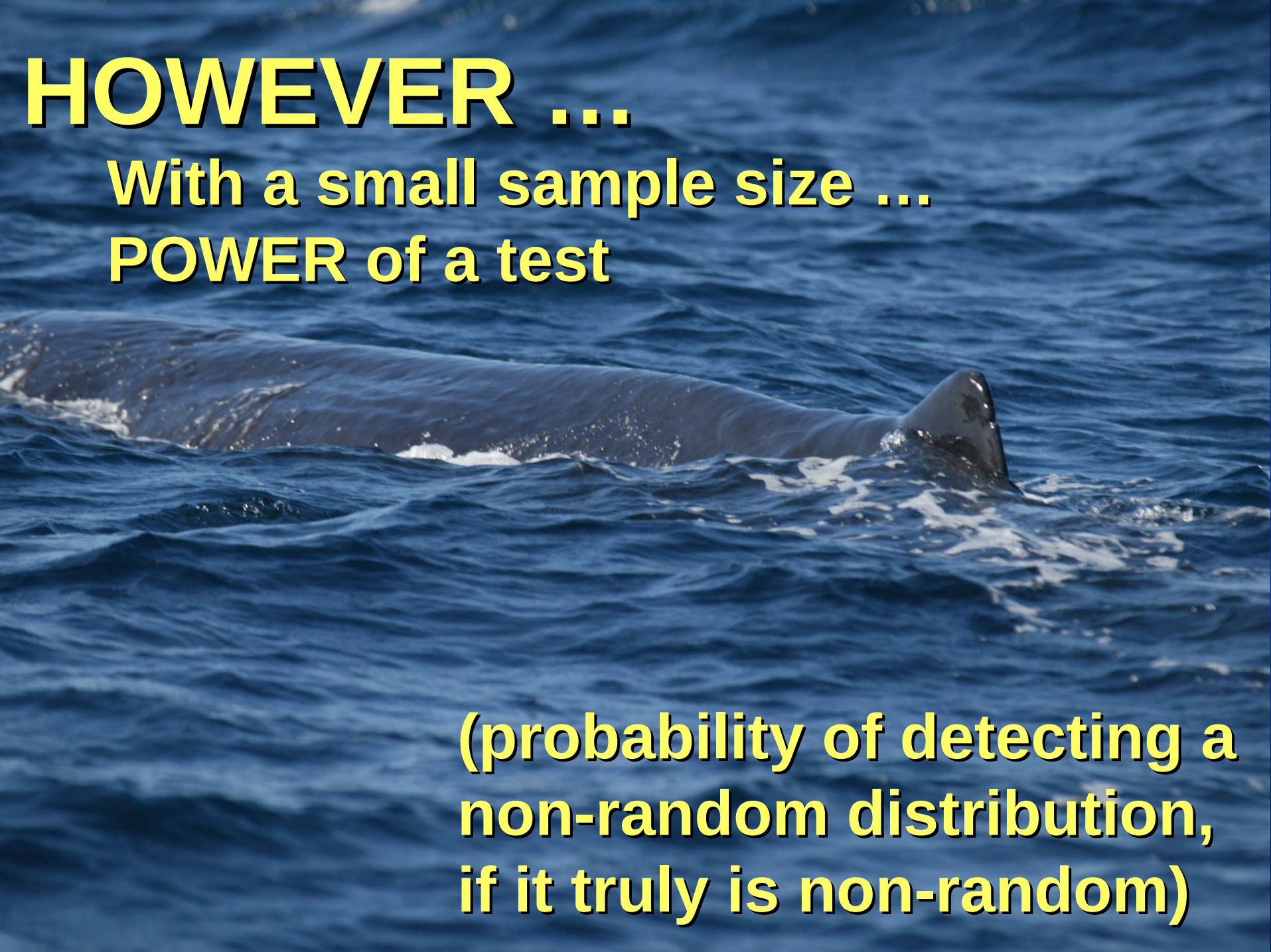


Chi-Square Test for Non-Randomly Distributed Distances



Compare observed distances to expected distances normalized to the proportion of area the class represents $p = 0.71$

No evidence ($p<0.05$) that data are non-randomly distributed.

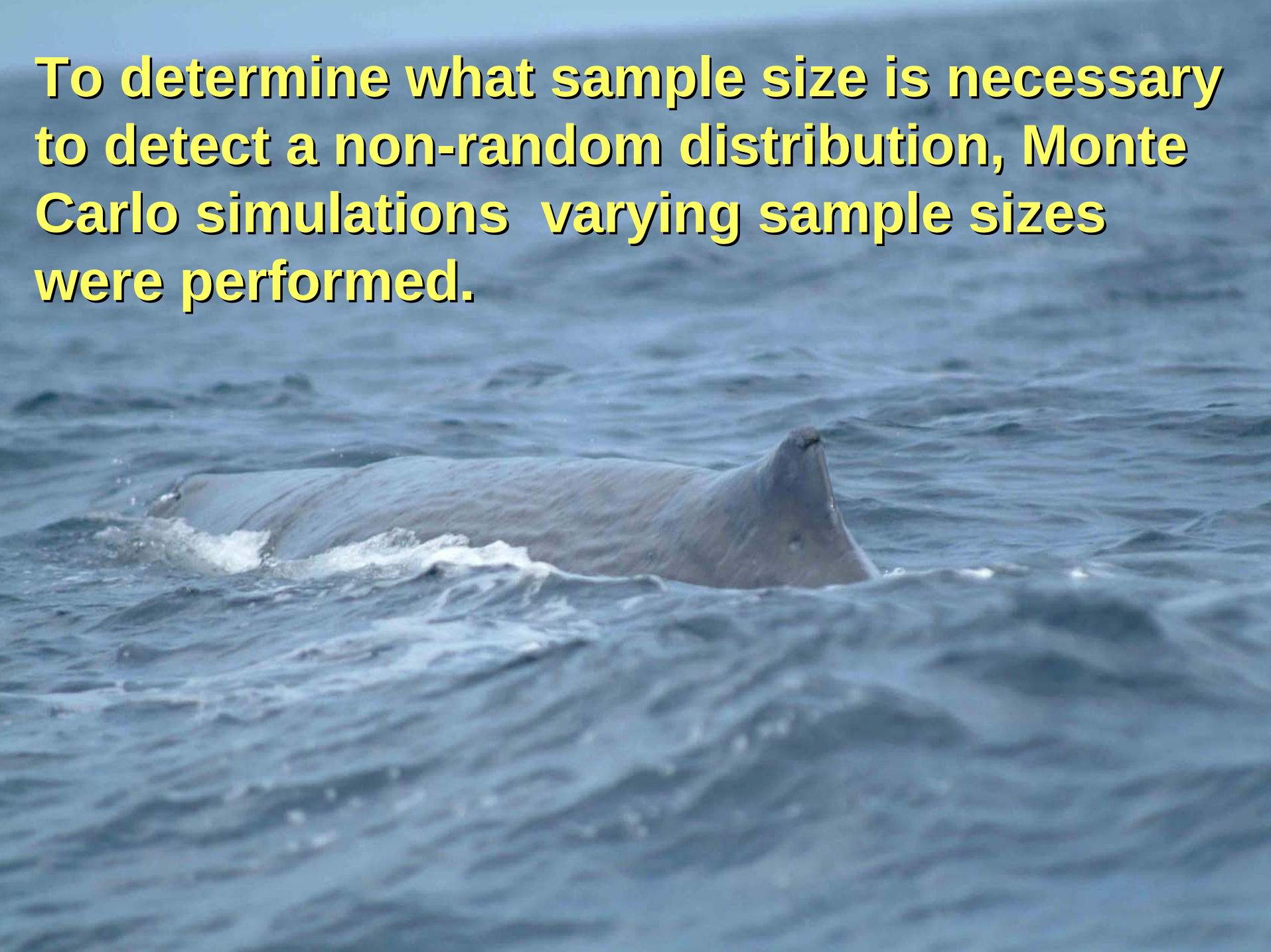


HOWEVER …

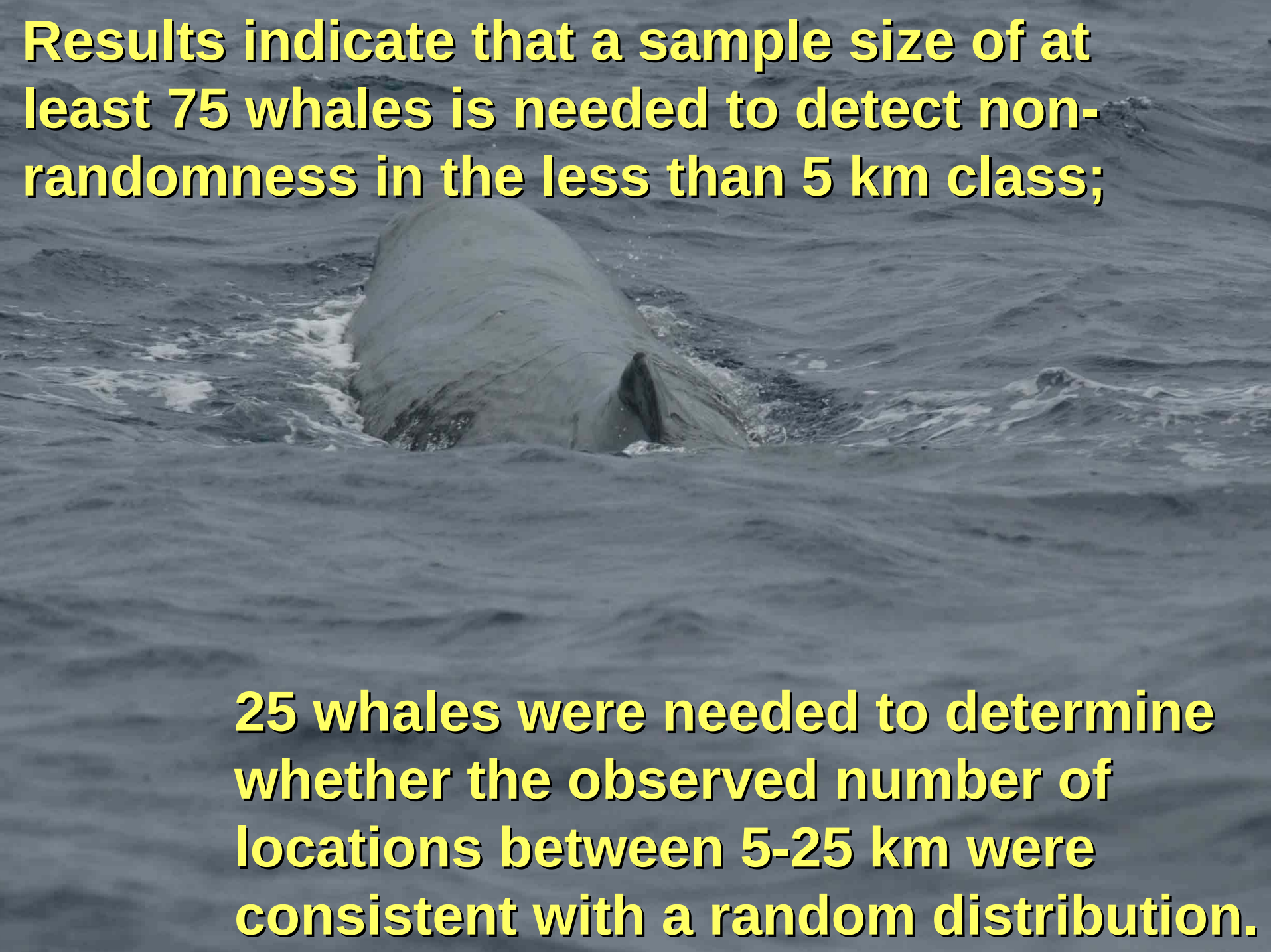
With a small sample size …

POWER of a test

(probability of detecting a non-random distribution, if it truly is non-random)



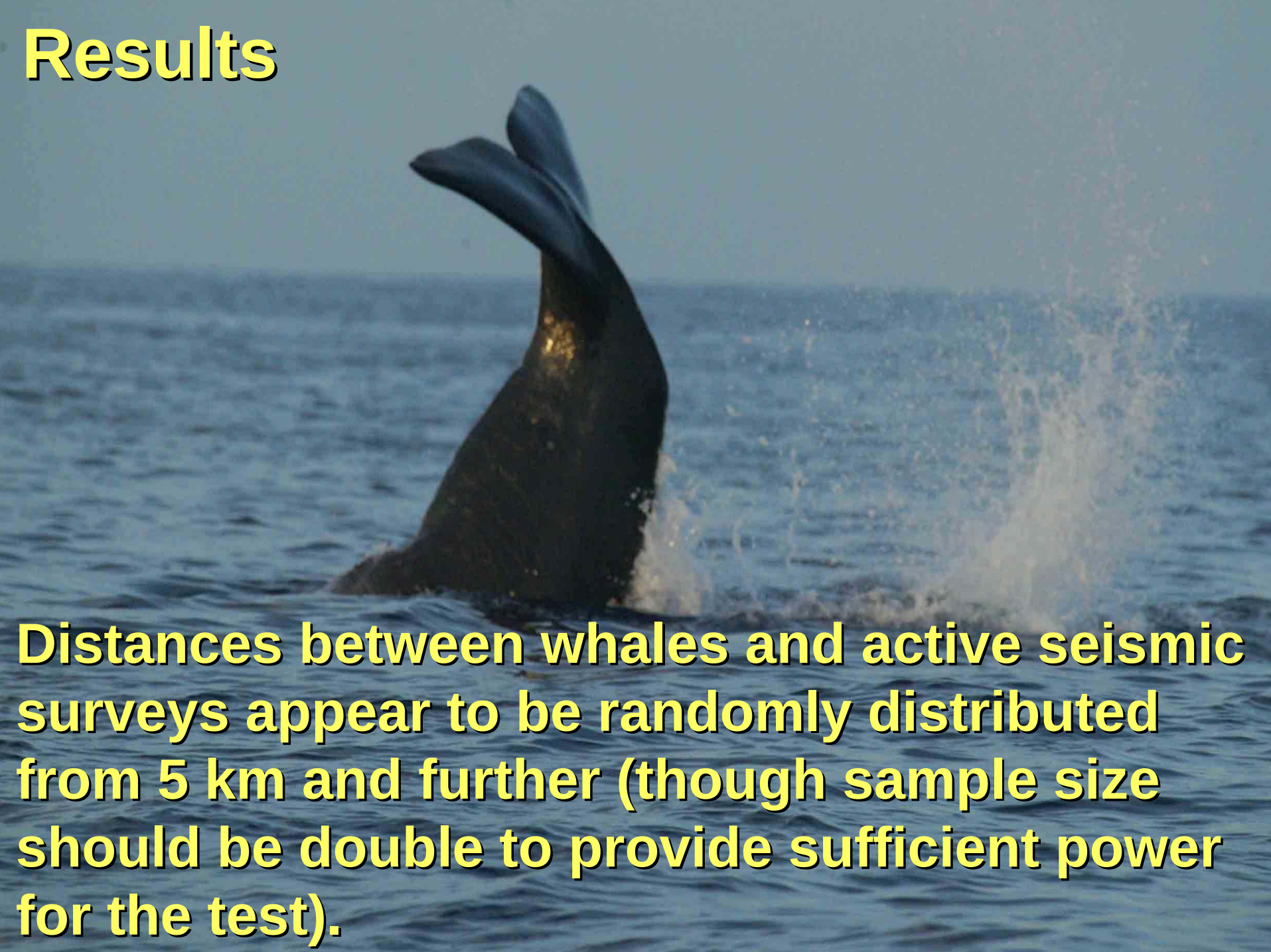
To determine what sample size is necessary to detect a non-random distribution, Monte Carlo simulations varying sample sizes were performed.



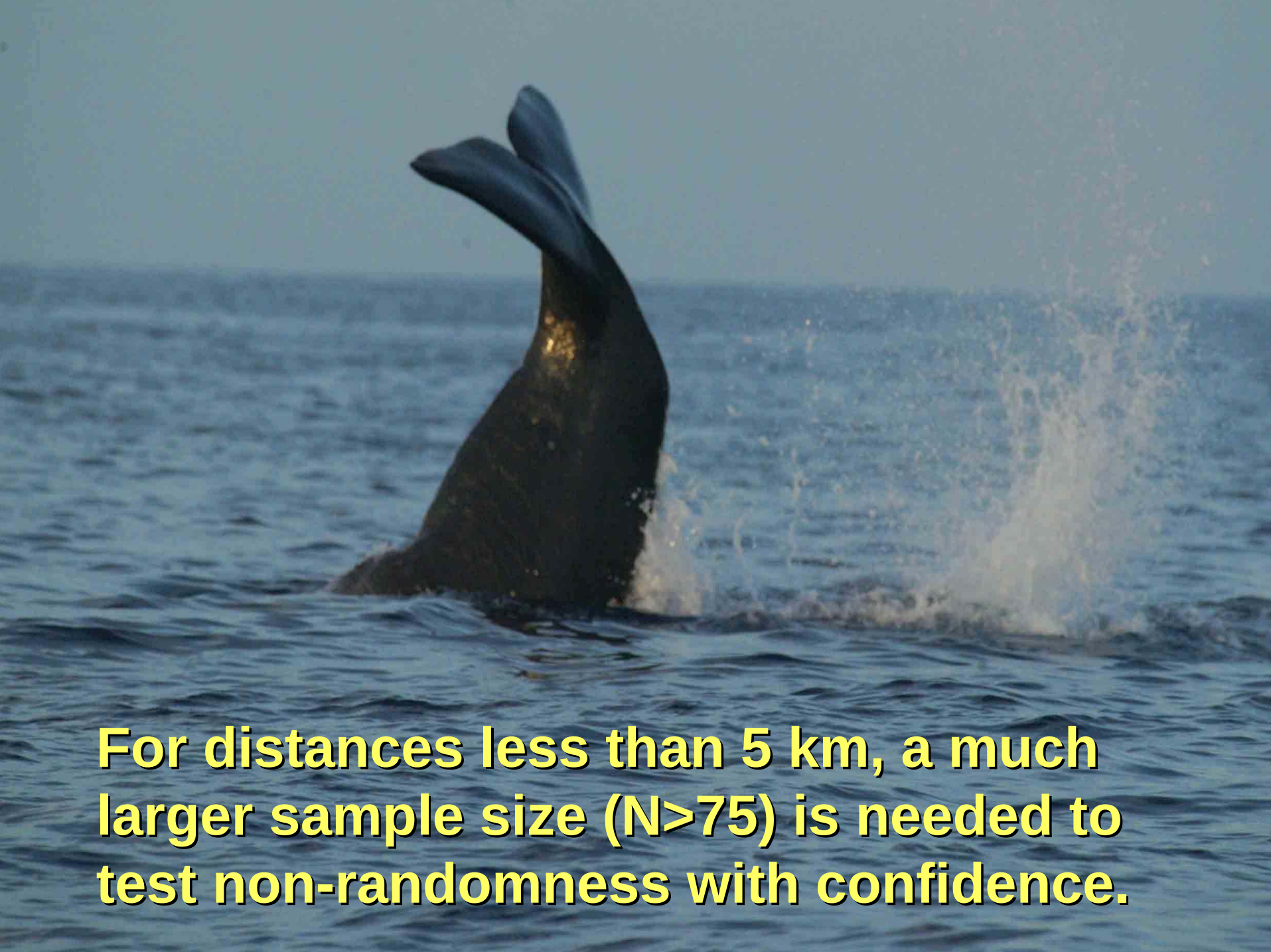
Results indicate that a sample size of at least 75 whales is needed to detect non-randomness in the less than 5 km class;

25 whales were needed to determine whether the observed number of locations between 5-25 km were consistent with a random distribution.

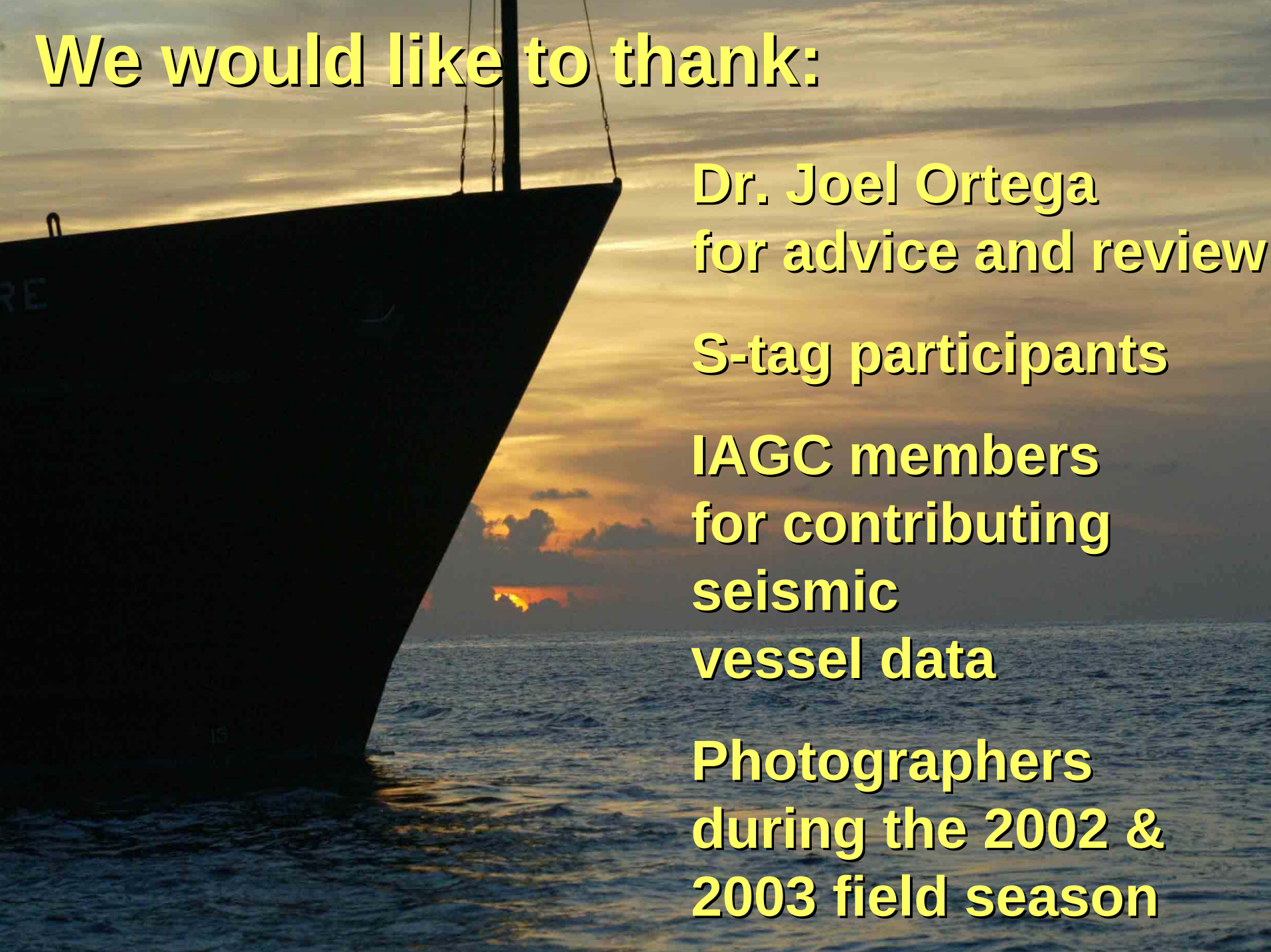
Results



Distances between whales and active seismic surveys appear to be randomly distributed from 5 km and further (though sample size should be double to provide sufficient power for the test).



For distances less than 5 km, a much larger sample size (N>75) is needed to test non-randomness with confidence.



We would like to thank:

Dr. Joel Ortega
for advice and review

S-tag participants

IAGC members
for contributing
seismic
vessel data

Photographers
during the 2002 &
2003 field season

Individuals with 10 or more locations within 100km of an active vessel

		Distance (km) from central shot point			
S-tag	Count	Mean	Std Dev	Min	Max
2505647	11	73.8	22.78	23.5	92.8
2505649	26	58.9	27.36	5.0	96.4
2505650	14	63.3	30.6	10.0	99.0
2505654	10	62.9	23	27.2	93.0
2505655	27	51.9	20.66	22.5	94.9
2505669	21	58.8	26.02	13.2	93.7
2505670	14	60.1	16.84	24.6	90.4
2505685	15	73.3	22.33	18.2	99.7
2505701	44	58.4	26.56	9.7	95.3
2505709	23	55.1	22.24	7.2	89.4
2505710	14	39.5	16.65	20.7	74.5
2505726	16	56.8	28.42	9.4	96.9
2800828	24	61.4	22.06	17.8	95.0
2801385	15	63.7	21.85	27.4	97.7
2805710	13	68.2	24.89	21.5	98.9

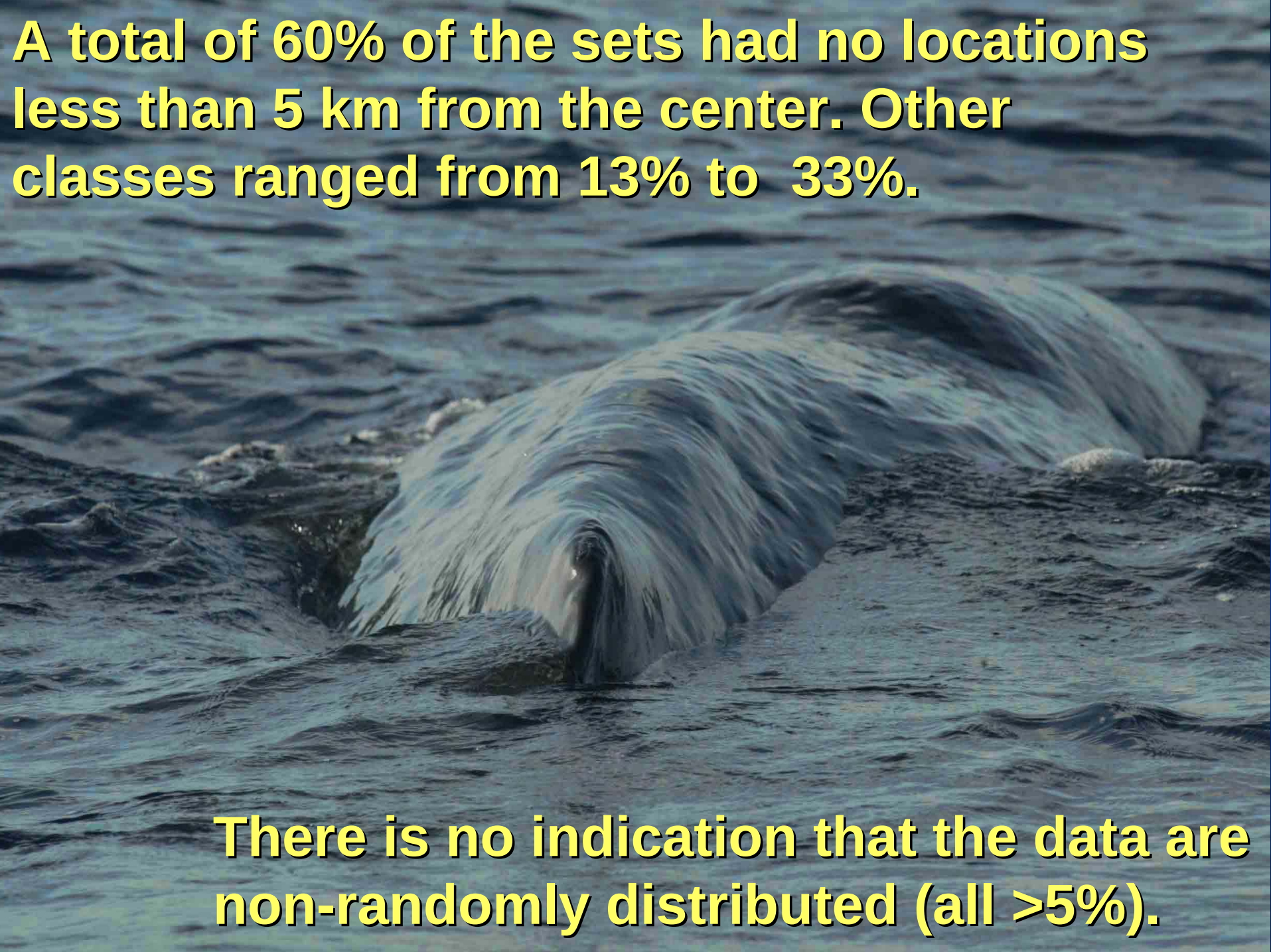
Monte Carlo Simulations

Produced 1000 sets of 12 randomly created locations within a 25 km radius of a central point.

Tabulation of the number of occurrences in each distance class for the observed data set and the expected number for an area-normalized randomly distributed data set (n=12).

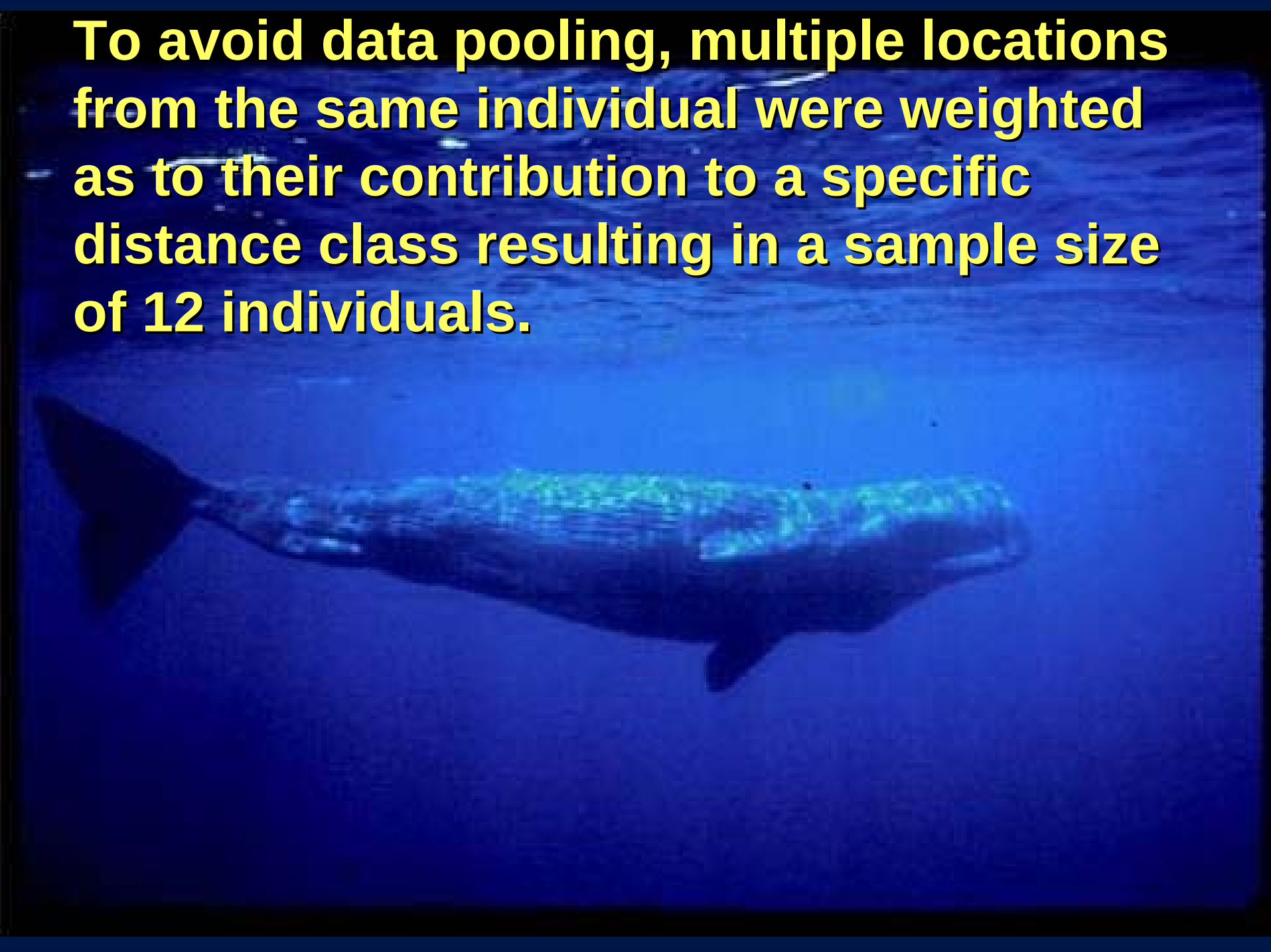
The mean and standard deviation of each distance class from a Monte Carlo simulation of randomly distributed locations (1000 sets of 12 distances) and the number of sets with the same number of class values as the observed.

Distance class	0–5 km	5–10 km	10–15 km	15–20 km	20–25 km
Observed data set count (n=12)	0	1.33	0.83	4.25	5.58
Area-normalized randomly distributed count (n=12)	0.48	1.44	2.4	3.36	4.32
Mean (std dev) of Monte Carlo sets (n=1000)	0.5 (0.71)	1.4 (1.16)	2.4 (1.41)	3.3 (1.5)	4.4(1.66)
Monte Carlo sets[1] with value x	597 x=0	330 x=1	196 x=1	206 x=4	128 x=6



A total of 60% of the sets had no locations less than 5 km from the center. Other classes ranged from 13% to 33%.

There is no indication that the data are non-randomly distributed (all >5%).



To avoid data pooling, multiple locations from the same individual were weighted as to their contribution to a specific distance class resulting in a sample size of 12 individuals.