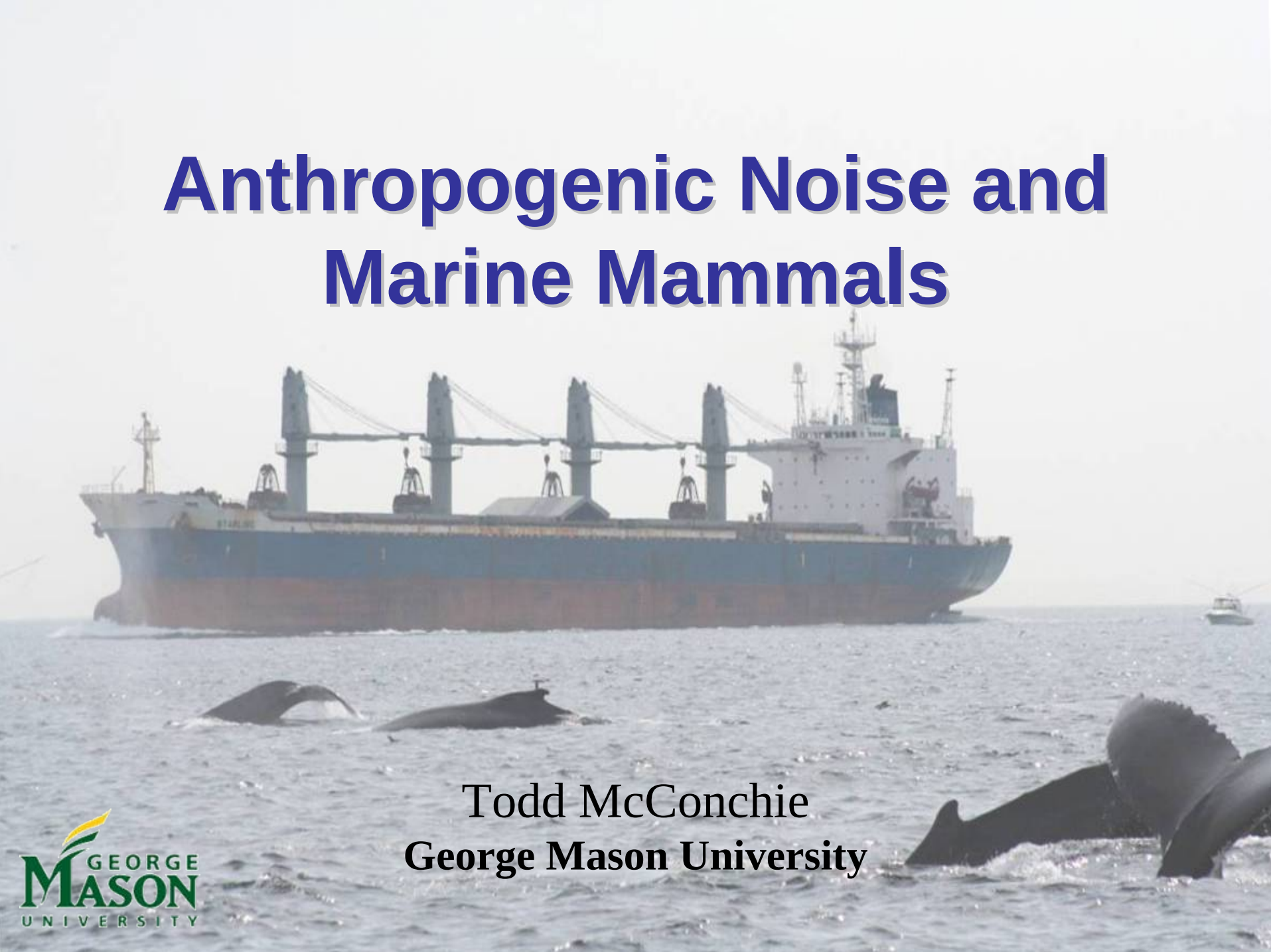
Anthropogenic Noise and Marine Mammals



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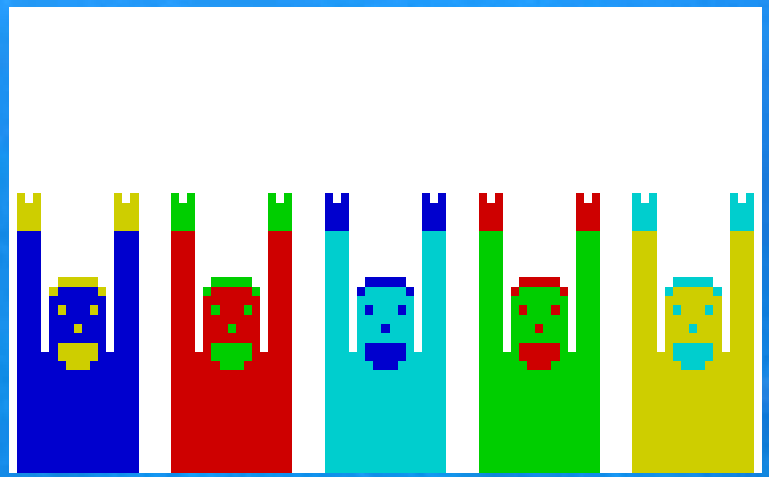
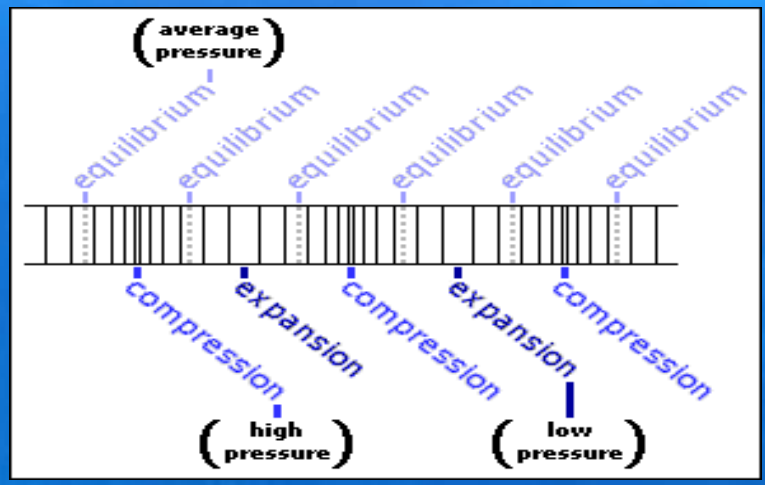
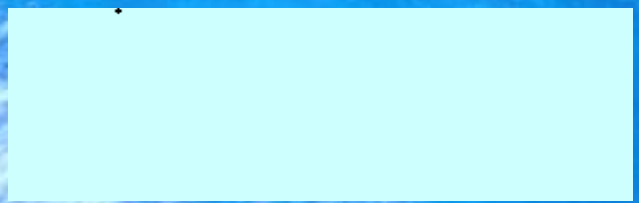
What is Sound?

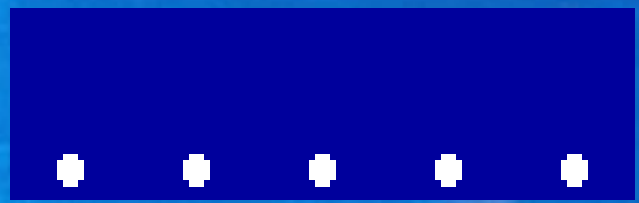
- A wave





- A transverse wave





What is Noise?

- “a nonharmonious or discordant group of sounds”
  - dictionary.com

- Unwanted sound

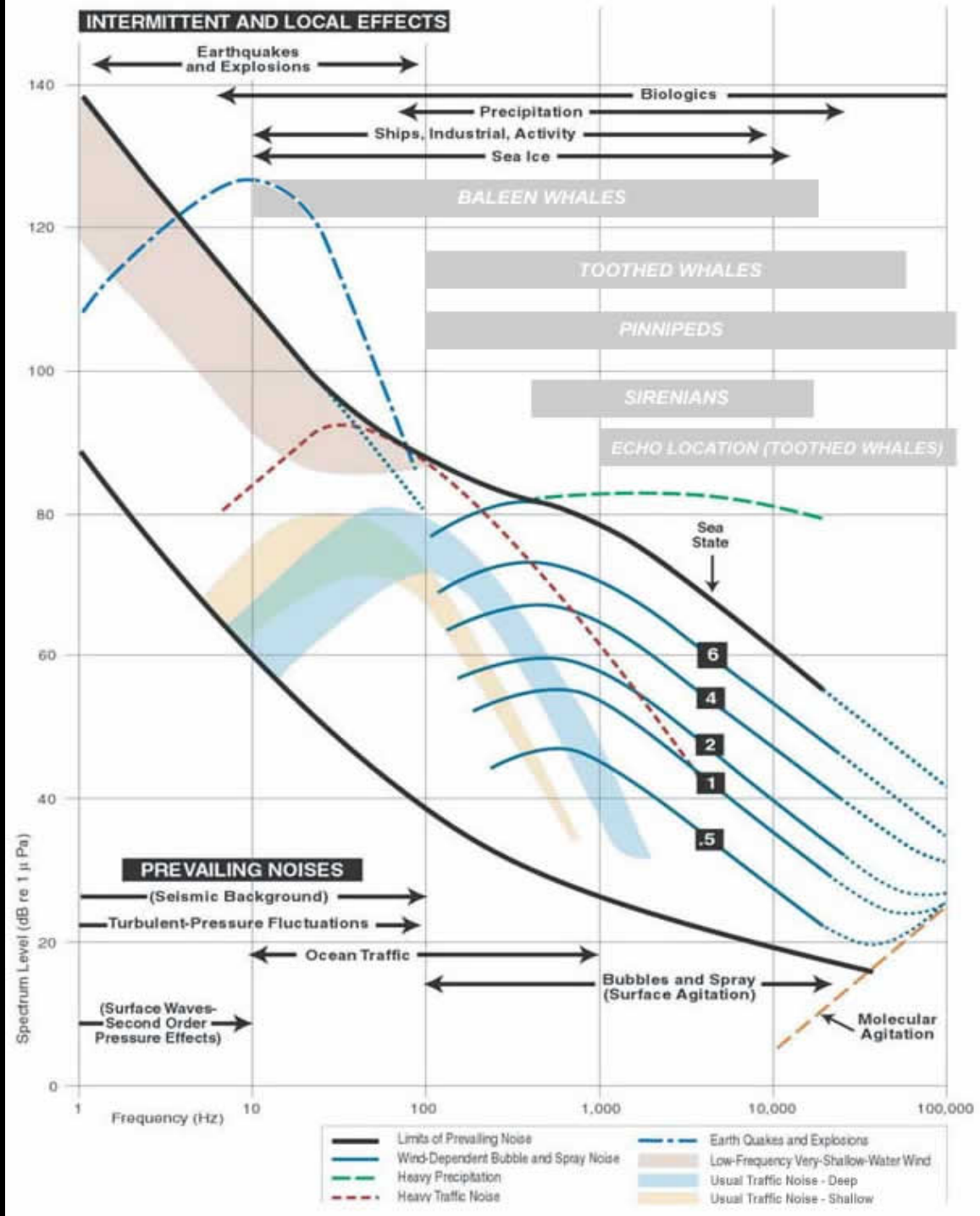
What types of noise are a concern for Marine Mammals?

Ambient Noise

- General noise in the environment
- Sources of Ambient Noise:
  - Wind or wave action on the sea surface
  - Rain or hail striking the sea surface
  - Seismic activity
  - Biologics
- May be persistent, or transient and intermittent
- May be Low (<1000 Hz), mid (1000 – 10,000 Hz) or high (>10,000 Hz) frequency

Anthropogenic Noise

- Man-made, introduced sound in the marine environment
- Sources of Anthropogenic noise:
  - Shipping
  - Seismic surveys
  - Military activities
  - Construction
- Tends to be centered at low frequencies
- Contributes to ambient noise
- Has been attributed to an overall increase in ambient noise in the ocean


INTERMITTENT AND LOCAL EFFECTS
Earthquakes and Explosions
Biologics
Precipitation
Ships, Industrial, Activity
Sea Ice
BALEEN WHALES
TOOTHED WHALES
PINNIPEDS
SIRENIANS
ECHO LOCATION (TOOTHED WHALES)
Sea State
6
4
2
1
.5
PREVAILING NOISES
(Seismic Background)
Turbulent-Pressure Fluctuations
Ocean Traffic
Bubbles and Spray (Surface Agitation)
(Surface Waves-Second Order Pressure Effects)
Molecular Agitation
Spectrum Level (dB re 1 μ Pa)
Frequency (Hz)
0
20
40
60
80
100
120
140
1
10
100
1,000
10,000
100,000
Limits of Prevailing Noise
Wind-Dependent Bubble and Spray Noise
Heavy Precipitation
Heavy Traffic Noise
Earth Quakes and Explosions
Low-Frequency Very-Shallow-Water Wind
Usual Traffic Noise - Deep
Usual Traffic Noise - Shallow

Responses to noise in the marine environment

- **Invertebrates**
  - Affects tend to be small
  - May include startle response
- **Birds**
  - Generally are able to leave the area quickly
- **Fish**
  - Are affected, but research into how is still relatively lacking
- **Sea turtles**
  - Hearing sensitivity appears to be mostly in the low frequencies
- **Marine mammals**
  - Appear to be the most affected by the widest range of sound in the ocean

Consequences of noise for Cetaceans

- Decreases ability to communicate
- May require re-organization of energy budgets
- May cause gross behavioral disturbances
- May lead to physical harm
- May ultimately cause death

Shipping lanes in the U.S.

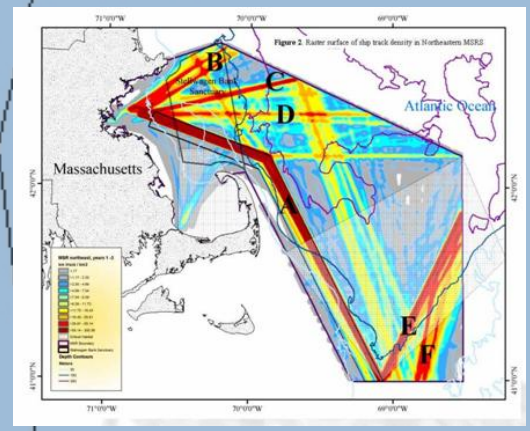
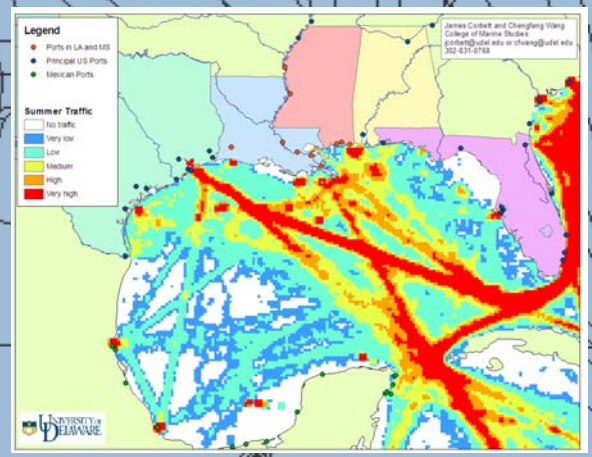


Figure 2. Raster surface of ship track density in Northeastern MSRS
B
C
D
A
E
F
Massachusetts
Atlantic Ocean


Legend
Ports in LA and MS
Principal US Ports
Mexican Ports
Summer Traffic
No traffic
Very low
Low
Medium
High
Very high
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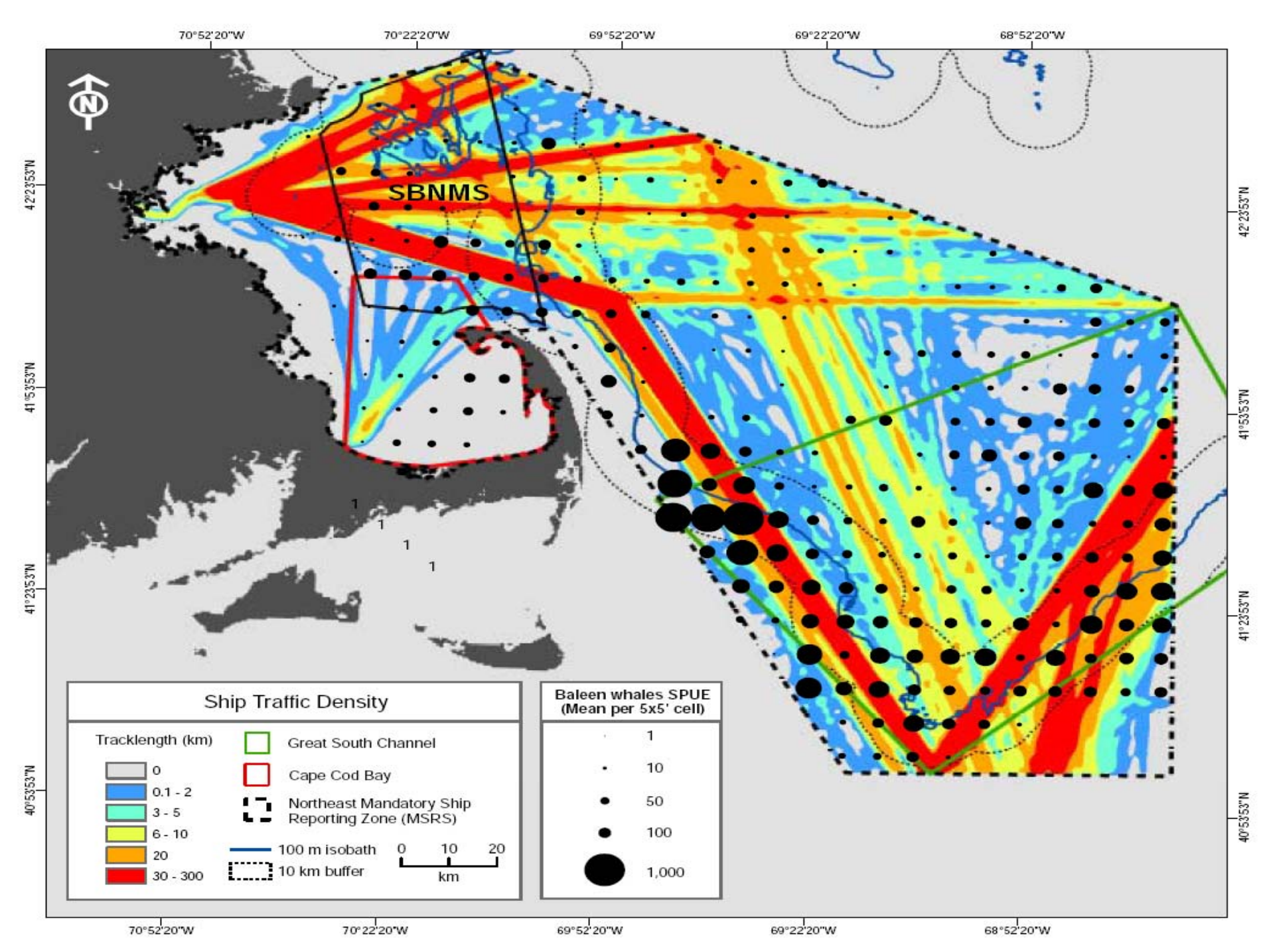
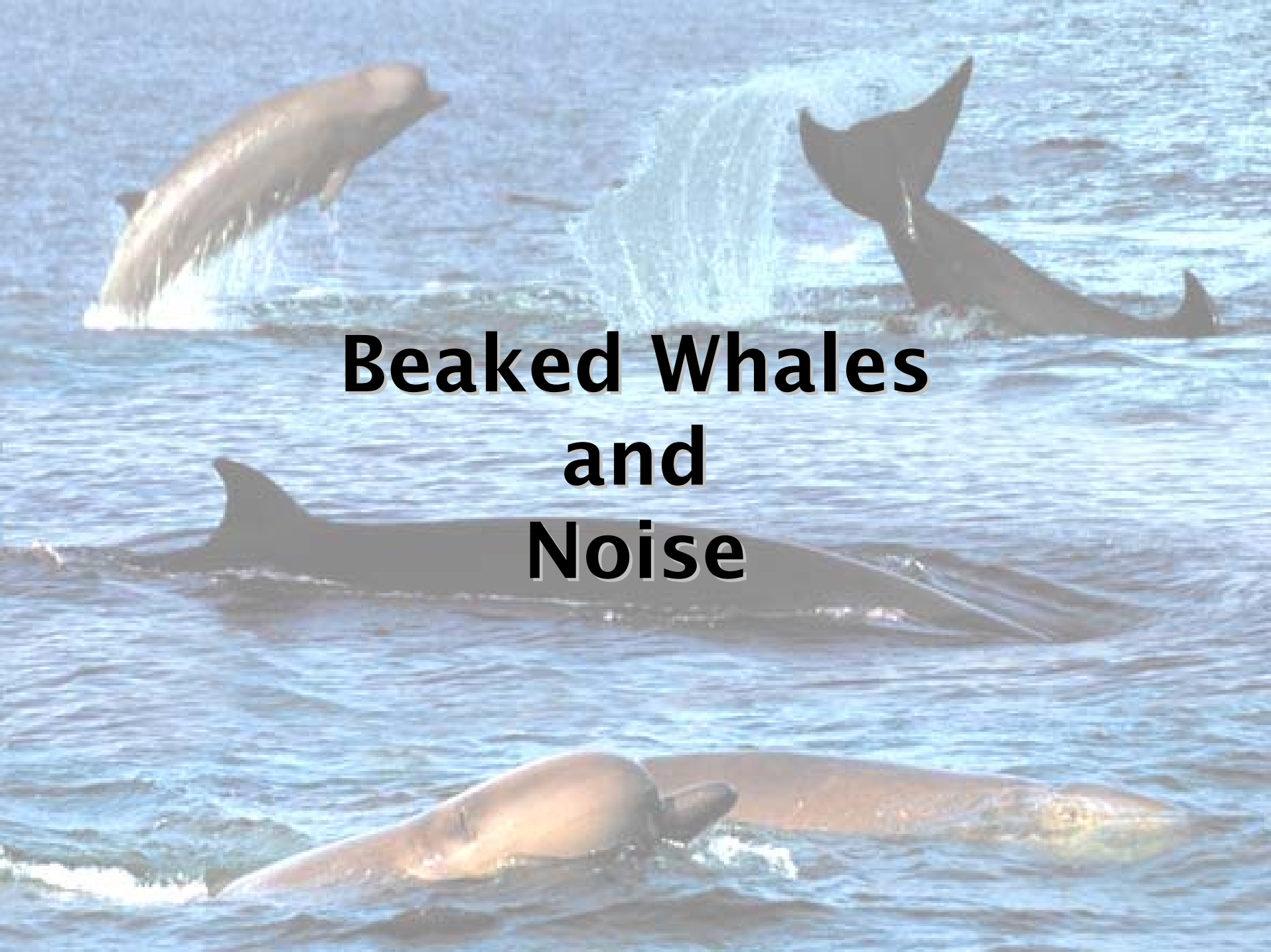

70°52'20"W
70°22'20"W
69°52'20"W
69°22'20"W
68°52'20"W
42°23'53"N
41°53'53"N
41°23'53"N
40°53'53"N
SBNMS
1
1
1
1
Ship Traffic Density
Tracklength (km)
0
0.1 - 2
3 - 5
6 - 10
20
30 - 300
Great South Channel
Cape Cod Bay
Northeast Mandatory Ship Reporting Zone (MSRS)
100 m isobath
10 km buffer
0 10 20
km
Baleen whales SPUE (Mean per 5x5' cell)
1
10
50
100
1,000



Beaked Whales and Noise

Beaked Whales

- Approximately 21 species
- Deep divers (>1000 m)
- Some species may dive for over an hour
- Seem to congregate in areas with deep canyons
- Seem to rely on specific dive profiles to mitigate effects of deep dives
- Spend relatively little time at surface

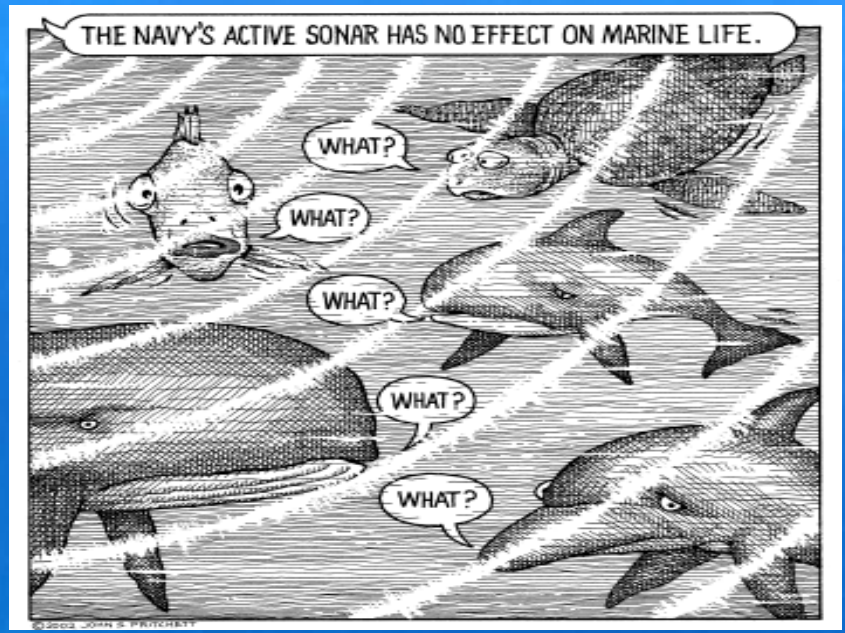
Some beaked whale mass stranding events

Locations	Beaked Whale species				Associated Naval activity when available
	Cuvier's	**Blainville's**	**Gervais'**	**Unid.**	
Greece May 1996	12				Naval LFA sonar trials & MFA sonar
Bahamas March 2000	9	3		2	Naval MFA sonar
Madeira May 2000	3				Naval MFA sonar
Canary Islands September 2002	7	3	1	3	Naval MFA sonar
Gulf of California September 2002				2	Seismic surveys
TOTAL	**22**	**6**	**1**	**7**	

Compiled from Cox et al, 2006

So…
Does Sonar kill whales?

- Depends on who you talk to
- High degree of correlation
  - But correlation does not necessarily lead to certainty



- Animals don't always strand when Navy uses sonar
- Consequences are mostly known, but the mechanisms are still being researched

What does it all mean???

- New England waters and the tropics are important feeding, mating and calving grounds for many marine mammal species.
- Noise in the ocean is definitely increasing.
- What are the cumulative effects of noise in the ocean?
- Stranding events as a result of acute noise will likely increase as the number and intensity of anthropogenic sound sources increase.
- What about the effects of masking, stress, decreased reproductive success, habitat abandonment?

Questions or Comments?