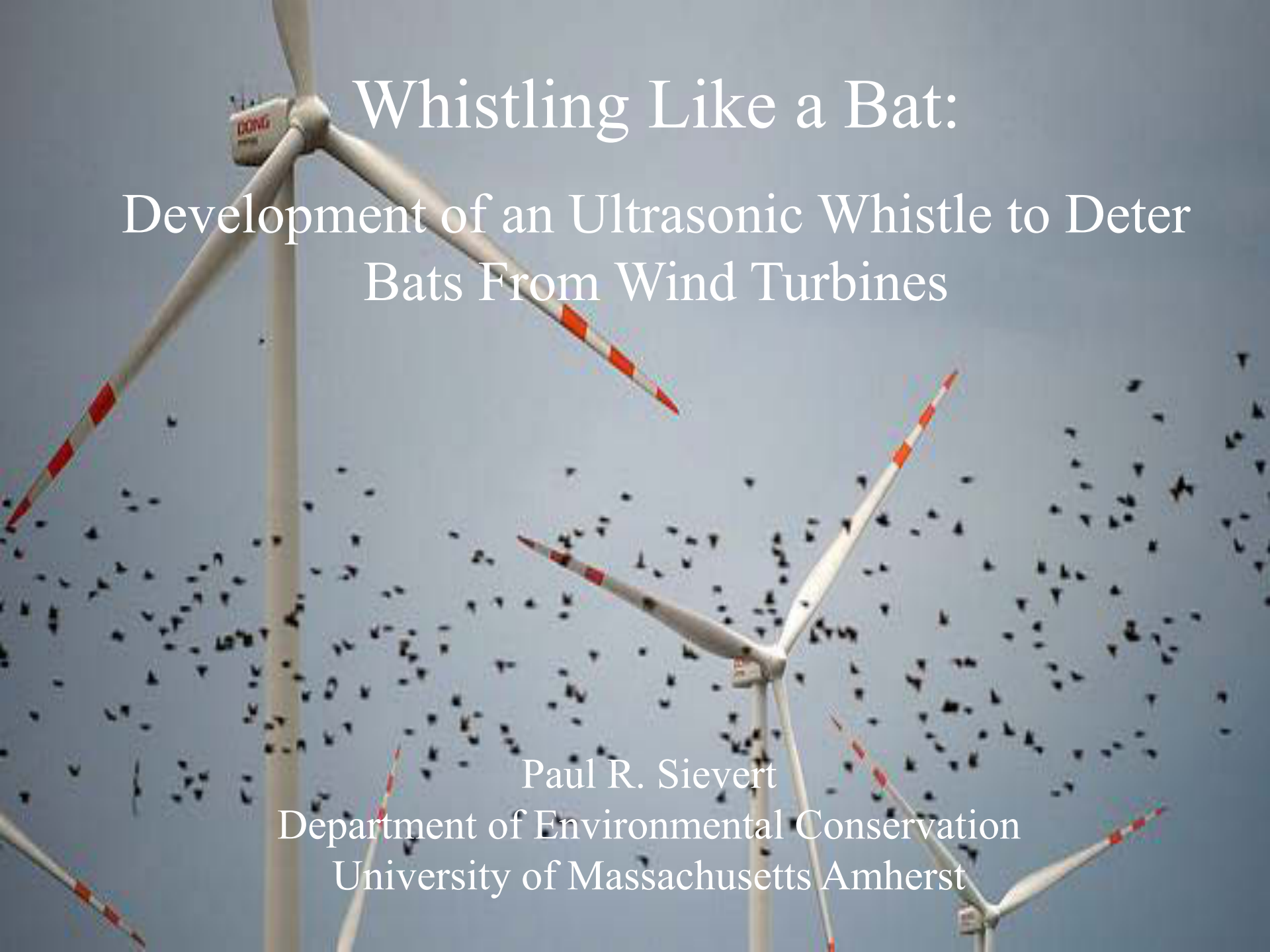
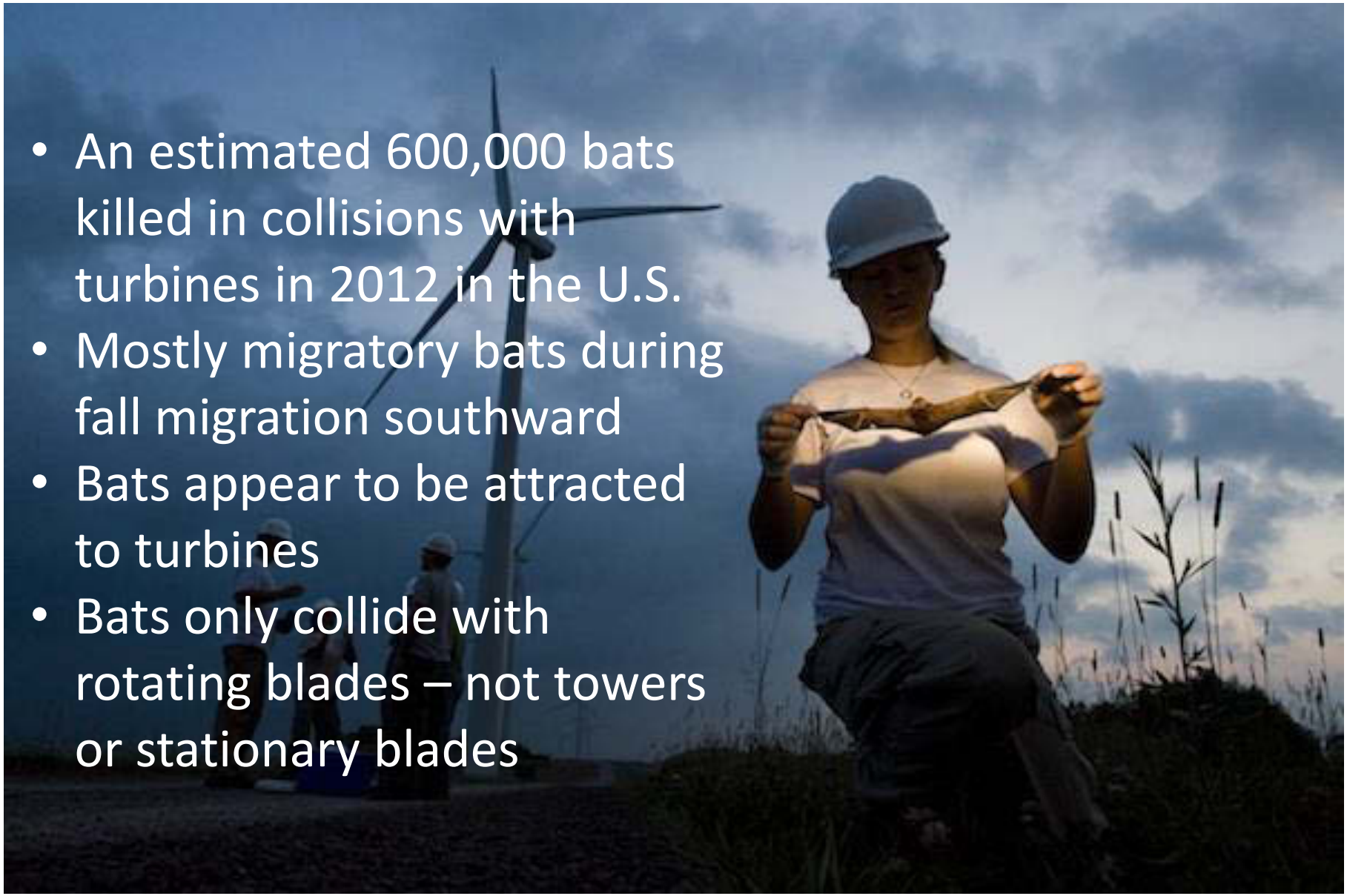


Whistling Like a Bat:

Development of an Ultrasonic Whistle to Deter Bats From Wind Turbines

Paul R. Sievert
Department of Environmental Conservation
University of Massachusetts Amherst

BAT MORTALITY AT WIND FACILITIES



- An estimated 600,000 bats killed in collisions with turbines in 2012 in the U.S.
- Mostly migratory bats during fall migration southward
- Bats appear to be attracted to turbines
- Bats only collide with rotating blades – not towers or stationary blades

Migratory Bats

Hoary Bat

Silver-haired Bat

Eastern Red Bat

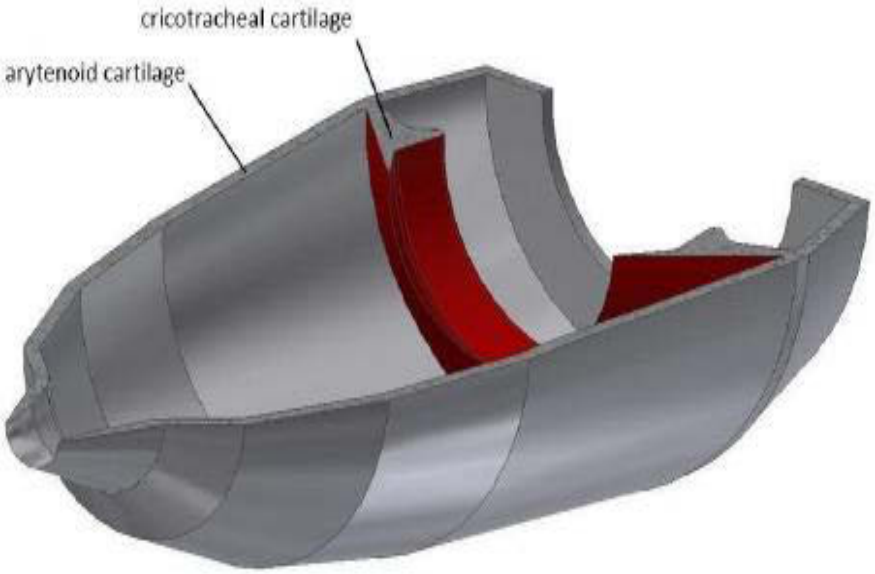
ULTRASOUND AS DETERRENT

- Attenuates quickly in the atmosphere
- Birds and large mammals (including people!) can't hear it
- Bats avoid "noisy" environments when foraging
- Bats can learn to avoid toxic moths which emit ultrasonic warning clicks

CURRENT DETERRENT TECHNOLOGY

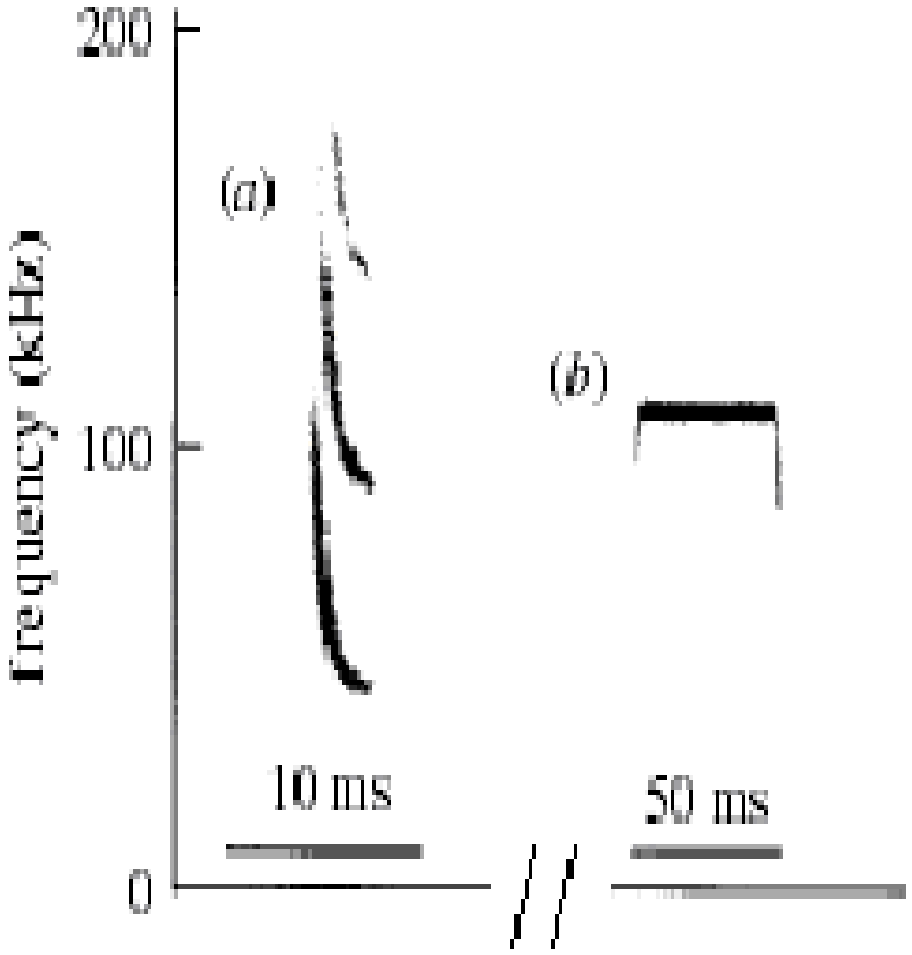
- Single tones do not appear to work (bats can alter call to avoid)
- Electrically-powered broadband ultrasonic noise generator
- 10-100 kHz range
- Success in lab trials and trials at foraging sites
- Not successful in reducing bat mortality when mounted on turbine nacelles

OUR PROPOSED SOLUTION



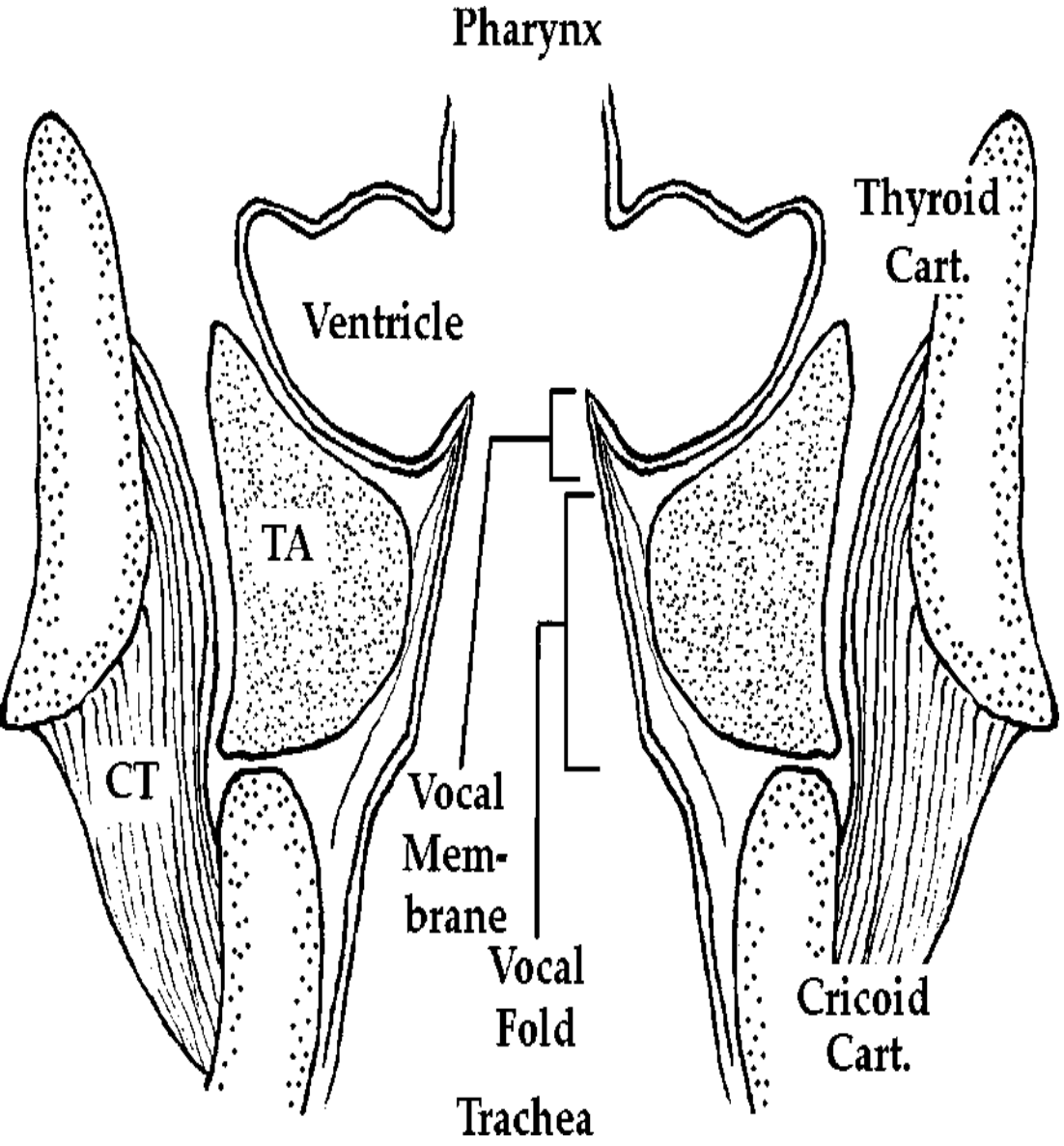
- Wind-blown whistles
- 25-55 kHz range
- Over wind speeds up to 6 m/s
- Blade speeds up to ~42 m/s
- Lower bound hard to predict
- Based on bat larynx, frequency-modulated

BAT ECHOLOCATION CALLS



- Frequency-modulated
- Constant frequency

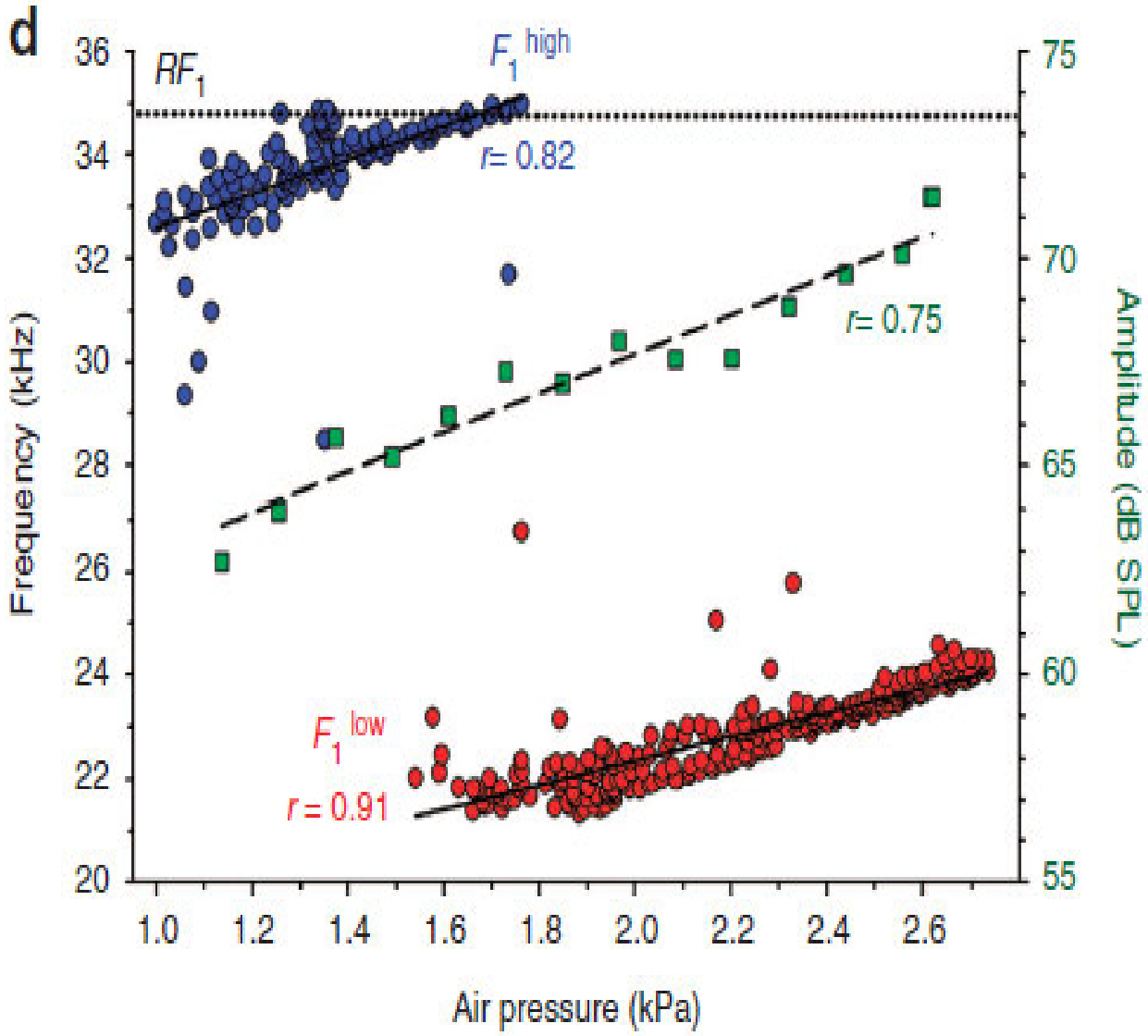
BAT LARYNX ANATOMY



Schematic coronal section through middle of larynx showing anatomy of the vocal membrane. The membrane projects upward (rostrally) from main body of vocal fold.

CT: Cricothyroid muscle.
TA: Thyroarytenoid (vocalis) muscle

EXCISED LARYNX VOCALIZATIONS



ENERGY.GOV

OFFICE OF ENERGY EFFICIENCY & RENEWABLE ENERGY

MASSACHUSETTS CLEAN ENERGY CENTER

NSF

IGERT

Integrative Graduate Education and Research Traineeship

UMass Wind Energy Center

UMass IGERT Offshore Wind Energy Program

Engineering, Environment, and Policy

National Science Foundation Integrative Graduate Education and Research Traineeship Program

UMassAmherst

The Bat Whistle Team

TEXAS A&M UNIVERSITY

Yahya Modarres-Sadeghi

Banafsheh Seyed-Aghazadeh

Daniel Carlson

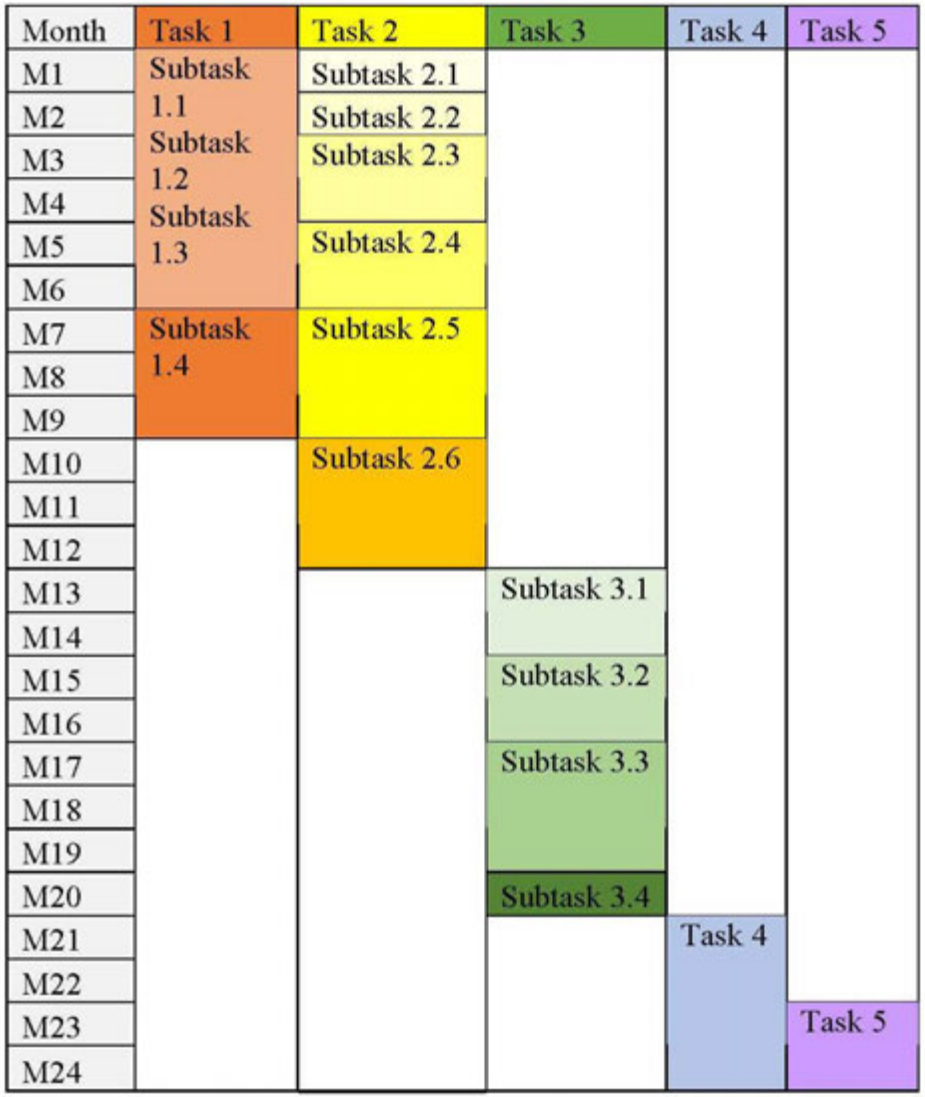
Matthew Lackner

Elizabeth Dumont

Zara Dowling

Michael Smotherman

Task 1: Characterize bat avoidance responses to ultrasound regimes
Task 2: Design initial biomimetic prototype
Task 3: Develop series of prototype whistles operating over range of frequencies
Task 4: Test prototype whistle series on bats in laboratory
Task 5: Test prototype whistles on wind turbine



TEXAS A&M UNIVERSITY

Mexican Free-Tailed Bat

Task 1: Characterize bat avoidance responses to ultrasound regimes

- Capture wild bats
- Perform Y-maze selection trials
- Perform perch selection trials
- Evaluate free-flying bat trajectories

Tri-colored Bat

Little Brown Bat

Big Brown Bat

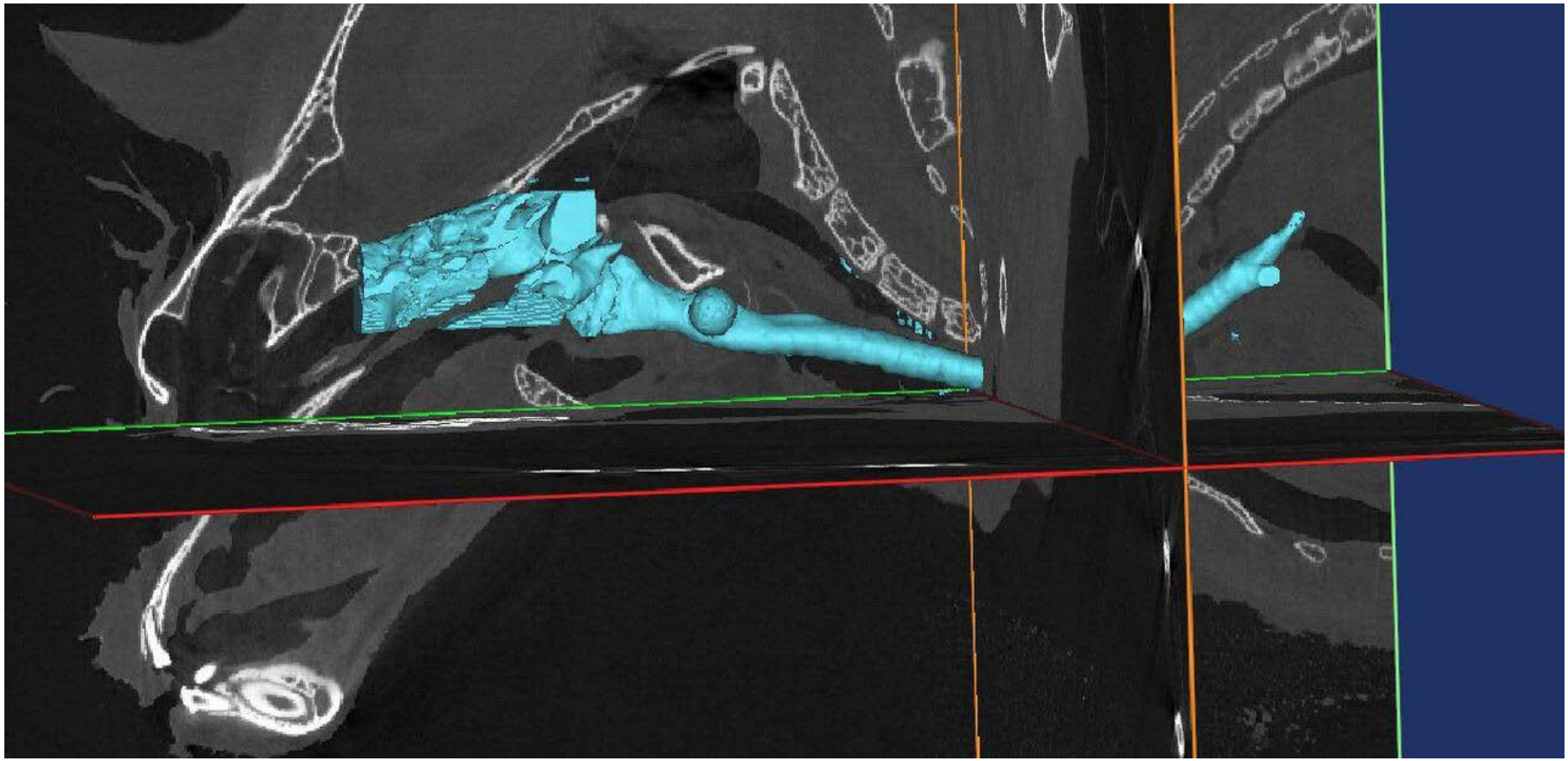


Task 2: Design initial biomimetic prototype

- Obtain candidate biological models
- Analyze candidate biological models
- Determine initial biological model through physical prototyping
- Increase sound power level of prototype
- Generate sound across range of wind speeds from prototype
- Generate frequency-modulated output from prototype

Task 3: Develop series of prototype whistles operating over range of frequencies

- Design a frequency-modulated whistle operating at ~ 25-35 kHz
- Design a frequency-modulated whistle operating at ~ 35-45 kHz
- Design a frequency-modulated whistle operating at ~ 45-55 kHz
- Recording of ultrasonic regimes produced by whistles operating in concert



TEXAS A&M UNIVERSITY

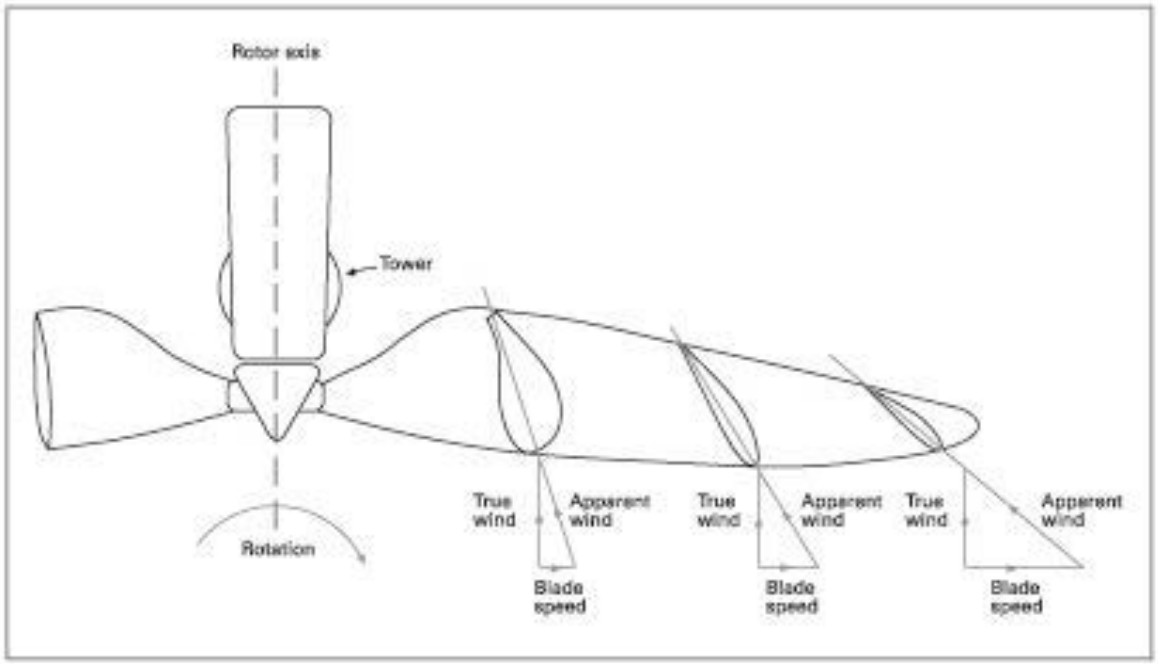
Task 4: Test prototype whistle series on bats in laboratory

Tri-colored Bat

Little Brown Bat

Big Brown Bat

Task 5: Test prototype whistles on wind turbine



Blade twist

Future Directions: Test Effectiveness of Bat Whistles in the Field


Thank you!