Project Notes:

Project Title:
Name:Anthony DeRosa

Note Well: There are NO SHORT-cuts to reading journal articles and taking notes from them. Comprehension is paramount. You will most likely need to read it several times, so set aside enough time in your schedule.

Contents:

Knowledge Gaps:

This list provides a brief overview of the major knowledge gaps for this project, how they were resolved and where to find the information.

Knowledge Gap	Resolved By	Information is located	Date resolved
Reverse Osmosis	Reading a Journal article on reverse Osmosis	https://doi.org/10.1038/s41467-022-30555-6	8/20/23
Dielectricity	Reading a Journal article new dielectric material	https://doi.org/10.1126/sciadv.aax6622	8/20/23
How the environment conditions wind farms are in affects the sound pressure levels	Reading a journal article about an offshore wind farm simulation	https://ieeexplore.ieee.org/document/7890320	9/10/23
Sources of sound pollution from wind turbines in different environments	Reading a journal article about an offshore wind turbine and using a compact	https://www.sciencedirect.com/science/article/pii/S0306261922015288?via=ihub	9/17/23

	liner to reduce sound pollution		
Whether Biomimicry was used for making airfoils quieter	Searching Biomimcry to reduce airfoil sound emission, and finding a journal article studying owls.	https://www.mdpi.com/2076-3417/9/11/2224	9/22/23
What specific IV that could make wind turbine blades quieter, and what birds to use.	Deciding I could test different wind speeds, and the geometries of the wings themselves.	In thIn this document	11/1/23
What other birds fly silently like owls	I solved this by narrowing down what biological airfoils I will be using.	In this document+project notes	11/14/23

Literature Search Parameters:

These searches were performed between (Start Date of reading) and XX/XX/2019.
List of keywords and databases used during this project.

Database/search engine	Keywords	Summary of search
Google	Desalination	A general article giving the baseline information on desalination was shown within the first 10 listed articles.
Google	Reverse osmosis	An article on electrodialysis was shown within the first 5 listed articles.
Google (Science.org)	Alternative methods to reverse osmosis	A journal article looking at how modifying the reverse osmosis membranes made them more efficient.
Google(Nature Journal)	Reverse Osmosis membranes	A journal article on how the molecular nature of polyamide membranes in reverse osmosis were used to simulate the construction of these membranes, found within the first ten articles.
Google (Science)	Capacitor	Within the first 15 articles listed, a journal article on better materials for capacitors was found.
Scopus- (IEEEXPLORE)	Wind Turbine, sound	Within the first 10 articles, I found an article simulating where to put wind turbines to cause the least harm to aquatic animals.
Scopus (ScienceDirect)	Wind turbine and sound absorption	After scrolling through articles for a minute, I found my 7th source about reducing the underwater noise from a offshore wind turbine.

Google	animals as models for efficient airfoils to decrease noise	I found lots of articles, and this particular article about studying owls as a model to attempt to make airfoils quieter was one of the first 5 results.
Science Direct	Wind Turbine and sound	I quickly found an article about the increase in use of wind turbines and their effect on energy and sound levels.
Google	Bird Wing Bionic Airfoil	This was the third article that showed up, and it is an article about the design of a wind turbine blade based on a bird's wing.
Google	How airfoils work	A found a couple of articles that are useful in determining the basic foundation of how airfoils work.
Google	Wind Turbine Blade	I found lots of articles, the purpose of this search was to find one that went into greater detail about wind turbine blades, I found it within 2 minutes.
Scopus	Whale flippers influence on wind turbine blades	Within the first 20 articles, I found a journal article about an airfoil model after certain aspects possessed by a whale flipper.
Google	What Birds Fly Silently Like Owls	I found a journal article about the specific aspects of owl wings that make them quieter, and another article stating other birds that fly silently.
Google	Where does the sound come from on wind turbines	I found three different articles I am adding to my project notes regarding wind turbine noise.

Google	Bat Wings Inspiration Airfoils	I found an article talking about the acoustics of bird and bat wings.
Google	Wind turbine sound	I found some articles pretty quickly to deepen my understanding about the sound made by wind turbines.

Tags:

Tag Name	
Diffusion Map	Desalination
Reverse Osmosis	Economic Capacitor materials
Wind Turbine	Taiwan
Clean Energy/Green Energy	Wind Turbine Scaling, Land use
Circular Liner	Bionic Blade
Blade Design	Cumulative Impact
Morphological Adaptations	Animal flight
hatchling	Trailing edge noise
Wing membrane	Nightbirds

Bat flight	Fossil Soft Tissue
Trailing edge	Wind Turbine
Low-noise	

Article #1 Notes: Title

Article notes should be on separate sheets

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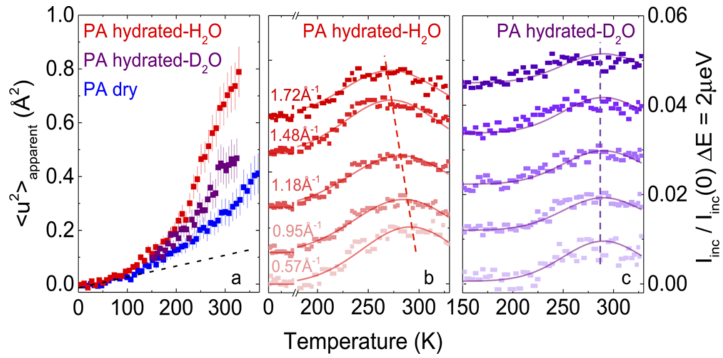
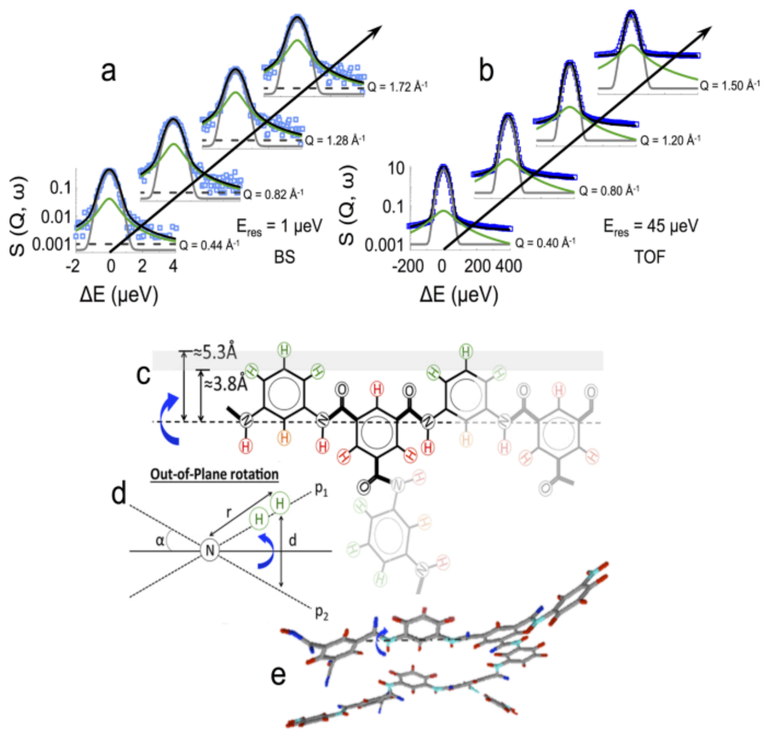
Source Title	
Source citation (APA Format)	
Original URL	
Source type	
Keywords	
#Tags	
Summary of key points + notes (include methodology)	
Research Question/Problem/ Need	
Important Figures	
VOCAB: (w/definition)	
Cited references to follow up on	
Follow up Questions	

Article #1 Notes: Multimodal confined water dynamics in reverse osmosis polyamide membranes

Article notes should be on separate sheets

Source Title	Multimodal confined water dynamics in reverse osmosis polyamide membranes
Source citation (APA Format)	Foglia, F., Frick, B., Nania, M. *et al.* Multimodal confined water dynamics in reverse osmosis polyamide membranes. *Nat Commun* 13, 2809 (2022). https://doi.org/10.1038/s41467-022-30555-6
Original URL	https://doi.org/10.1038/s41467-022-30555-6
Source type	Journal Article
Keywords	Multimodal, reverse osmosis, polyamide membranes (PA), diffusion map
#Tags	Desalination, Reverse Osmosis, Diffusion map
Summary of key points + notes (include methodology)	The exact molecular nature of polymers in the polyamide membranes isn't known. Neutron spectroscopy was utilized and determined how water diffuses multiple ways through the polyamide membranes as well as the geometry and timing of the mode. Using a diffusion simulation polyamide membranes can be designed. *Notes aren't paraphrased -The demand for fresh water is increasing, and becoming more and more of a problem. -Reverse Osmosis utilizes thin polyimide membranes, which are currently the most efficient method of desalination. -Molecular dynamic simulations of polyamide membranes during diffusion usually show that diffusion constants are one order magnitude lower than bulk water. -Neutron time of flight and backscattering spectroscopy were utilized to examine the molecular nature of desalination. -Both dry and wet polyamide membranes were used during this experiment. -Rotational relaxations in the polymer network were made in the polymer network. -Translational diffusion with a coefficient half of that of bulk water can be represented by a jump-diffusion model.

Research Question/Problem/ Need	How does reverse osmosis work at a molecular level, regarding the polyamide membranes under specific conditions?
Important Figures	 **Fig. 1: Mean-square displacement and IFWS of dry and hydrated PA membranes.**  **Fig. 2: QENS data and schematic of dry PA relaxation. These represent how Polyamide membranes look when dry.**

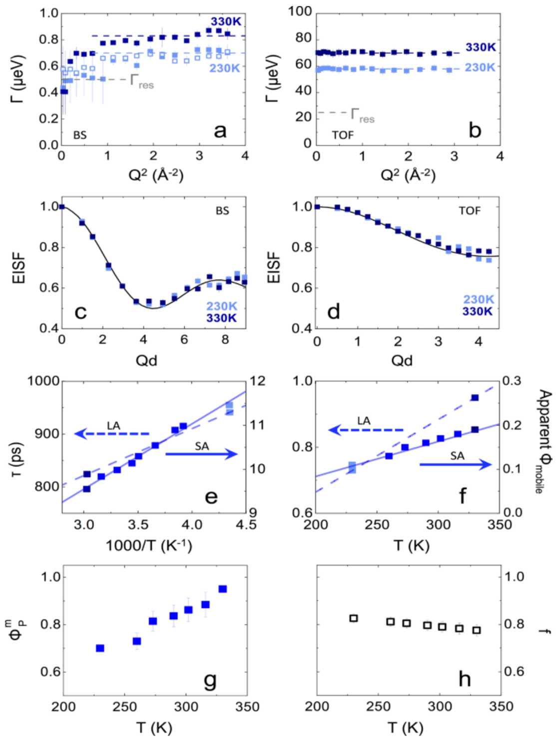


Fig. 3: Dry PA analysis of QENS data. These graphs go into the molecular relationships occurring when the polyamide membranes are dry.

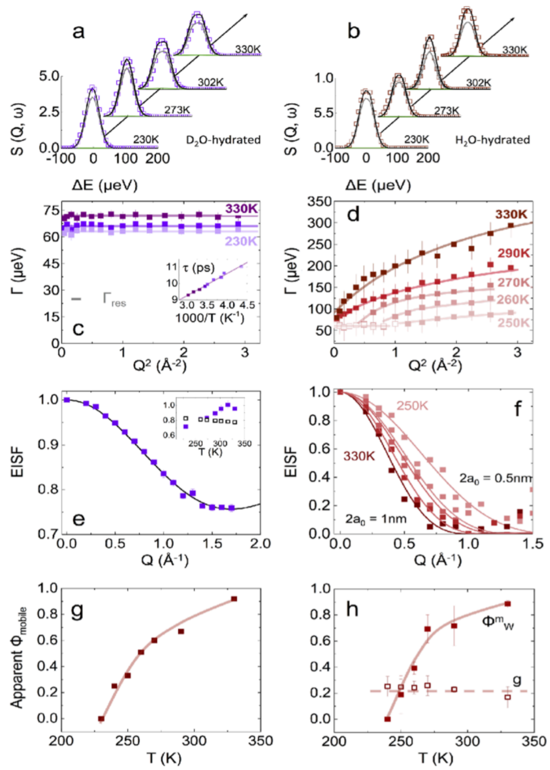
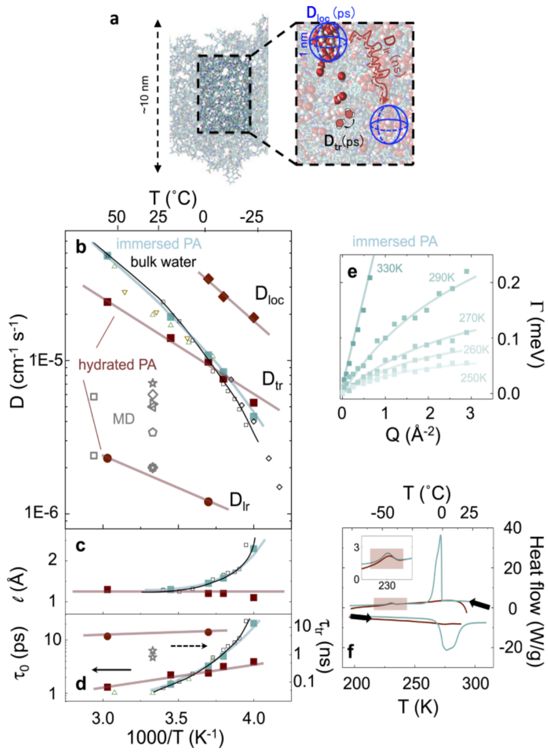


Fig. 4: Hydrated (vapor) PA analysis of QENS data. These graphs show the molecular relationships when the polyamide membranes are wet.

	 **Fig. 5: Confined water-diffusion map and contrast with bulk water. These graphs demonstrate the differences**
VOCAB: (w/definition)	1. Polymeric membranes-used in separation and purification processes, including water desalination. 2. Reverse osmosis-a method of desalination involving membranes that filter out salt and aid in the purification of water. 3. Desalination-the process of separating salt in salt water from water creating fresh water. 4. Neutron Spectroscopy-measures the atomic and magnetic motions of atoms. -ISIS Neutron Spectroscopy 5. Interface polymerization-a type of condensation polymerization in which polymerization occurs at an interface between an aqueous solution containing one monomer and an organic solution containing a second monomer.-Science Direct 6. Multimodality-the interplay between different representational modes.-Science Direct 7. Diffusion map- anchors molecular and nanoscale simulations
Cited references to follow up on	1. Greenlee, L. F., Lawler, D. F., Freeman, B. D., Marrot, B. & Moulin, P. Reverse osmosis desalination: water sources, technology, and today's challenges. *Water Res.* 43, 2317–2348 (2009). 2. Barker, R. W. *Membrane Technology and Applications* (John Wiley

	& Sons, Ltd., 2012). 3. Shannon, M. A. et al. Science and technology for water purification in the coming decades. *Nature* 452, https://doi.org/10.1038/nature06599 (2008). 4. Pendergast, M. M. & Hoek, E. M. A review of water treatment membrane nanotechnologies. *Energy Environ. Sci.* 4, 1946–1971 (2011). 5. Werber, J. R., Osuji, C. O. & Elimelech, M. Materials for next-generation desalination and water purification membranes. *Nat. Rev. Mater.* 1,
Follow up Questions	1. Could the water diffusion map predicting the molecular models of created be utilized to create more economic methods of desalination? 2. How would this water diffusion map be changed when predicting the molecular and nanoscale simulations of a charged polyamide membrane involved with electrodialysis? 3. Would this water diffusion map still work in predicting the water diffusion/purification of water contaminated by a variety of chemicals?

Article #2 Notes: A highly scalable dielectric metamaterial with superior capacitor performance over a broad temperature

Article notes should be on separate sheets

Source Title	A highly scalable dielectric metamaterial with superior capacitor performance over a broad temperature
Source citation (APA Format)	Zhang, T., Chen, X., Thakur, Y., Lu, B., Zhang, Q., Runt, J., & Zhang, Q. M. (2020). A highly scalable dielectric metamaterial with superior capacitor performance over a broad temperature. *Science Advances*, *6*(4). https://doi.org/10.1126/sciadv.aax6622
Original URL	https://doi.org/10.1126/sciadv.aax6622

Source type	Journal Article
Keywords	Dielectric material, capacitor, electric fields, polymers
#Tags	Economic capacitor materials
Summary of key points + notes (include methodology)	At temperatures around 150 degrees celsius polymers dielectric as well as electric functions diminish. Nano-fillers at low volumes cause changes in polymer structures resulting in more efficient electric and dielectric function during high temperatures and high electric fields. Changes in microstructure also affect dipole motions, the free path for mobile charges, and deep trap level. *Notes aren't paraphrased-general blurbs on what happened -Dielectric materials aid in storing and quickly releasing lots of energy. -Biaxially oriented polypropylene film capacitors have a fairly high energy density, with a large charge/discharge efficiency, making it often the capacitor of choice. -These capacitors require a low operating temperature-less than 80 degrees celsius, requiring them to have an external cooling system that is expensive. -The dielectric constant and breakdown field can be increased by local structural changes. -These changes can be caused by semicrystalline dipolar polymers and polyurethane nanofillers that are at low volumes. -Conduction loss is therefore reduced during high energy fields and higher temperatures. - Polymers with low nanofiller volumes make high discharged energy density that have good efficiency at 150 degrees celsius. -It was also found that microstructure changes in nanocomposites at 0.2 percent of nanofiller loading dipole motion constraints to be locally reduced when the polymer was in a glassy state, as well as the free mobile charges mean path, and the deep trap level was make stronger.
Research Question/Problem/ Need	How do nano-fillers create changes structurally in the polymers at high-temperatures and low volumes?
Important Figures	

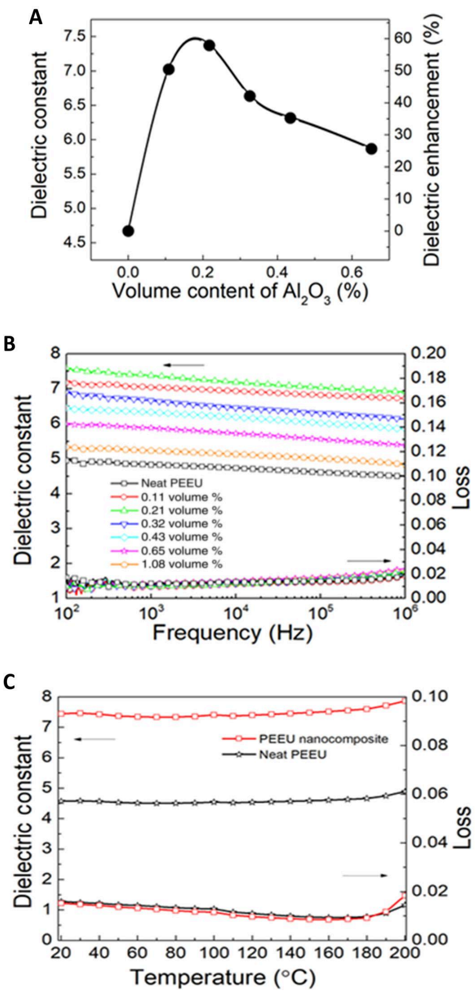


Fig. 1 Dielectric properties.-These graphs show the relationship between the different frequencies, columns, and temperatures in their relationship with the dielectric constant.

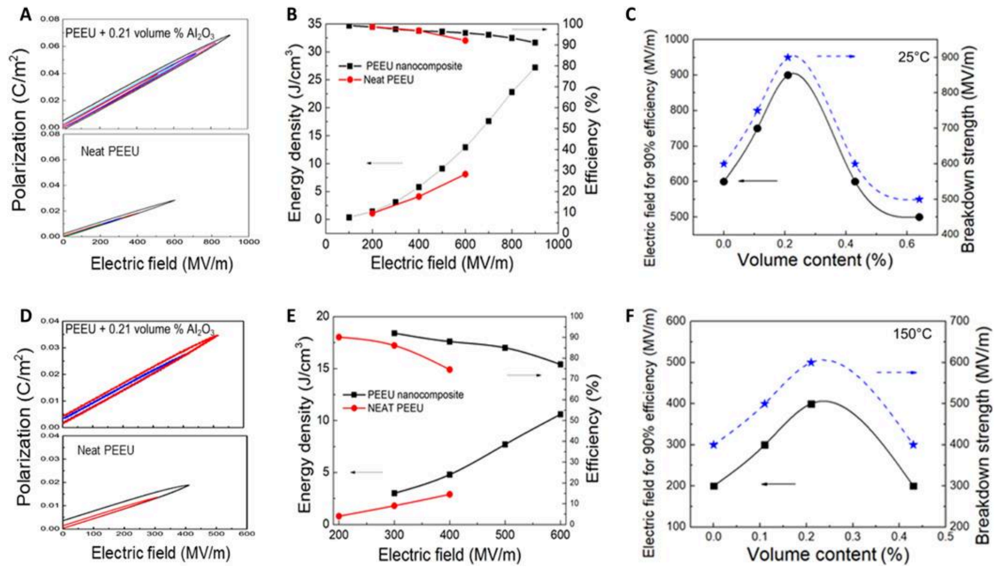


Fig. 2 C/D efficiency and energy density. These graphs show the relationship between volume, polarization, the breakdown strength, the electric field, and the energy density.

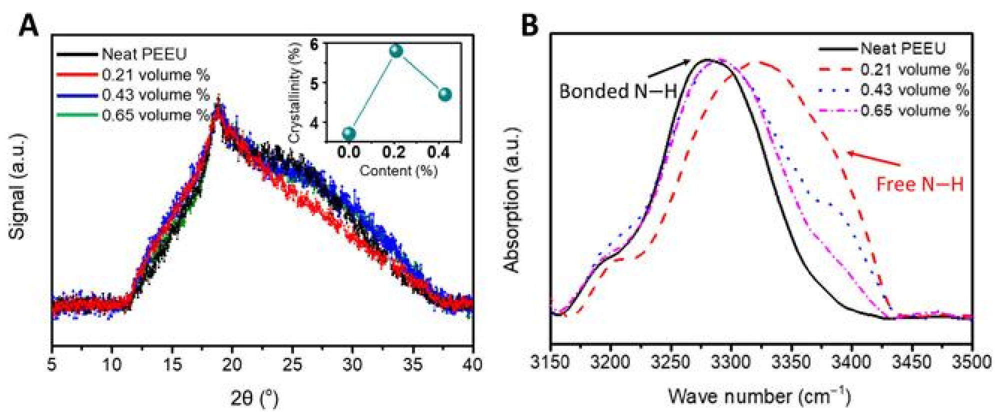


Fig. 3 XRD and FT-IR data. These two graphs demonstrate the relationship between signals and absorption, and their effect on the wave number.

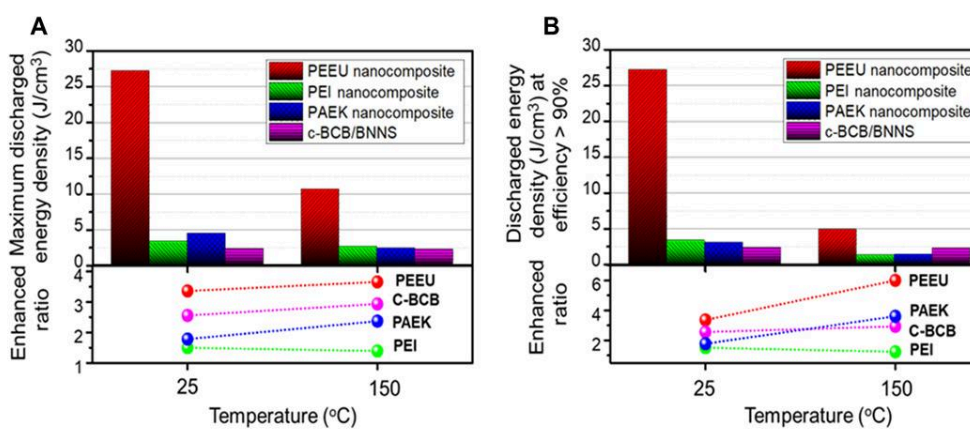


	Fig. 4 Electrical energy storage capability. These two graphs show the relationship between the amount of energy discharged and different temperatures.
VOCAB: (w/definition)	1. Dielectric materials-play a key role in electronic and electric devices and systems for controlling and storing charge and electric energy. 2. nanofillers-fillers with particle sizes in the 1–100 nm range. ScienceDirect 3. Semicrystalline polymer-constitute the largest fraction of industrial plastics used for fabrication of fibers, films, blends, and composites.-Science Direct 4. Electric field- an electric property associated with each point in space when charge is present in any form.-Britannica 5. Mean free path-the average distance that a particle can travel between two successive collisions with other particles.-ScienceDirect 6. Deep trap states-state in which the charge is immobile and confined within a small region of the material.-Arxiv.org
Cited references to follow up on	W. J. Sarjeant, J. Zirnheld, F. W. MacDougall, Capacitors. *IEEE Trans. Plasma Sci.* **26**, 1368–1392 (1998). B. Chu, X. Zhou, K. Ren, B. Neese, M. Lin, Q. Wang, F. Bauer, Q. M. Zhang, A dielectric polymer with high electric energy density and fast discharge speed. *Science* **313**, 334–336 (2006). L. An, S. A. Boggs, J. P. Calame, Energy storage in polymer films with high dielectric constant fillers. *IEEE Electr. Insul. Mag.* **24**, 5–10 (2008). A. Azizi, M. R. Gadinski, Q. Li, M. A. AlSaud, J. J. Wang, Y. Wang, B. Wang, F. H. Liu, L.-Q. Chen, N. Alem, Q. Wang, High-performance polymers sandwiched with chemical vapor deposited hexagonal boron nitrides as scalable high-temperature dielectric materials. *Adv. Mater.* **29**, 1701864 (2017).
Follow up Questions	1. What other effects do the structural changes in nano-fillers have on the polymers properties? 2. How does this change in structural changes in the nano-fillers affect the polymers properties in cold temperatures? 3. How does radiation or interference from RF energy impact the performance characteristics of these polymers?

Article #3 Notes: Why Desalination doesn't work (yet)

Article notes should be on separate sheets

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Source Title	Why Desalination doesn't work (yet)
Source citation (APA Format)	Michael, Schirber. (2007, June 25). *Why Desalination Doesn't Work (Yet)* [Science News Site]. Livescience.Com; Live Science. https://www.livescience.com/4510-desalination-work.html
Original URL	https://www.livescience.com/4510-desalination-work.html
Source type	Science News Site
Keywords	Desalination, reverse osmosis
#Tags	Desalination, Reverse osmosis
Summary of key points + notes (include methodology)	The need for fresh drinking water is continuously increasing, especially with growing populations and droughts. Reverse Osmosis is the most popular method of desalination, also being the cheapest method. The two biggest problems with reverse osmosis are the membrane pores getting clogged, and reverse osmosis uses lots of energy. *Notes aren't paraphrased-general blurbs on what happened -As the demand for fresh drinking water grows with the growing population, this resource is becoming harder and harder to obtain. -The reason seawater must be desalinated is because if someone were to drink regular seawater, they would become more dehydrated. -Currently roughly 10 to 13 billion gallons of water are desalinated daily, however this only accounts for 0.2 percent of water consumption in the world. -Sea water has been desalinated for thousands of years as sailors simply boiled salt water. However, desalination didn't take off until the 1950s when water filtering membranes were developed. -The problem is lots of energy is required to create the pressure to force the water through the membranes. -Both climate change bringing droughts and population growth have resulted in the rising demand for fresh water.

	-The two major problems right now are energy and gunk getting stuck in the pores of the membranes.
Research Question/Problem/ Need	What prevents desalination from being more commonly used?
Important Figures	None is this particular science new article
VOCAB: (w/definition)	Desalination-the process of removing salt from water Reverse Osmosis-method of desalination that forces water through membranes Membrane-filter used in reverse osmosis
Cited references to follow up on	There are no cited references
Follow up Questions	1. How could membranes be changed to minimize the frequency of them getting clogged? 2. Are there any other ways that could limit the amount of energy people have to put into reverse osmosis? 3. Could these reverse osmosis factories be put in areas that already have lots of pressure, limiting the amount of energy required?

Article #4 Notes: Don't wait, desalinate: A new approach to water purification

Article notes should be on separate sheets

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Source Title	Don’t wait, desalinate: A new approach to water purification
Source citation (APA Format)	Beckman Institute for Advanced Science and Technology. (2023, June 26). Don't wait, desalinate: A new approach to water purification: The future of clean water is electrified, according to chemists. *ScienceDaily*. Retrieved September 4, 2023 from www.sciencedaily.com/releases/2023/06/230626164240.htm
Original URL	https://www.sciencedaily.com/releases/2023/06/230626164240.htm#:~:text=Summary%3A,less%20energy%20than%20its%20counterparts.
Source type	Science News Article
Keywords	Electrodialysis, desalination
#Tags	Electrodialysis, desalination, redox reaction,

Summary of key points + notes (include methodology)	Electrodialysis is another method of water purification, separating salt and other particles from water. This electrified version of dialysis has been tested on waste water and proved successful. It requires 10 % of the energy used by its counterparts, and may be applied to rivers and oceans. *Notes aren't paraphrased-general blurbs on what happened -Electrodialysis is another method of purifying seawater. Electrodialysis works similarly to kidneys with the dialysis of blood, taking out waste. -Charged ion-exchange membranes are utilized in electrodialysis, these membranes only allow ions to pass through, and these are a large part of the reason electrodialysis is expensive. -Traditional electrodialysis splits water molecules into ions allowing only these ions to pass through the membranes. -A new method is now being utilized, a redox reaction that splits the water into cations and anions, filtering out salt just as efficiently using 90 % less energy. -Nanofiltration membranes are also replacing ion-exchange membranes to save energy.
Research Question/Problem/ Need	How does electrodialysis compare to its counterparts in terms of energy and success?
Important Figures	None
VOCAB: (w/definition)	Electrodialysis-an electrified version of dialysis, using charged ion membranes to separate water from salt via only letting ions pass through. Ions-charged particles Reduction-adding electrons to create a negative charge (chemistry) Oxidation-removing electrons to create a positive charge (chemistry) Redox reaction-adding a special polymer-based material to the wastewater before it's filtered and purified, changes the charge of the entire water molecule.
Cited references to follow up on	1. Nayeong Kim, Johannes Elbert, Choonsoo Kim, Xiao Su. **Redox-Copolymers for Nanofiltration-Enabled Electrodialysis**. *ACS Energy Letters*, 2023; 8 (5): 2097 DOI: 10.1021/acsenergylett.3c00482
Follow up Questions	1. How would electrolysis be implemented into rivers and the ocean? 2. If implemented into rivers, lakes, oceans, how would it affect the aquatic ecosystems that live there? 3. How could redox inspired electrodialysis be paired with solar panels?

Article #5 Notes: Metal-organic framework enables ultraselective polyamide membrane for desalination and water reuse

Article notes should be on separate sheets

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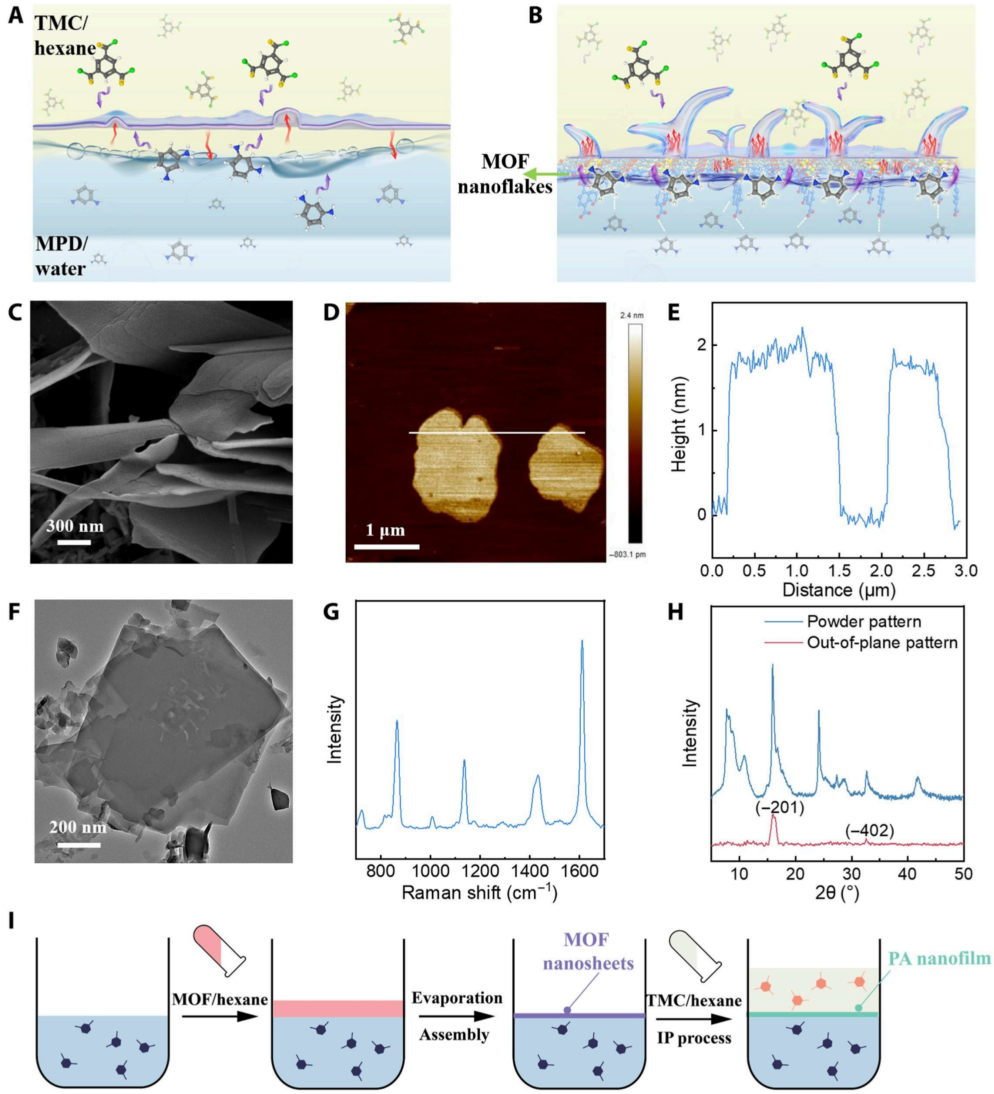
Source Title	Metal-organic framework enables ultraselective polyamide membrane for desalination and water reuse
Source citation (APA Format)	Wen, Y., Dai, R., Li, X., Zhang, X., Cao, X., Wu, Z., Lin, S., Tang, C. Y., & Wang, Z. (2022). Metal-organic framework enables ultraselective polyamide membrane for desalination and water reuse. *Science Advances*, *8*(10), eabm4149. https://doi.org/10.1126/sciadv.abm4149
Original URL	https://www.science.org/doi/10.1126/sciadv.abm4149
Source type	Journal Article
Keywords	Ultra-selective polyamide membrane, desalination
#Tags	Ultra-selective polyamide membrane, amphiphilic metal-organic framework
Summary of key points + notes (include methodology)	Because some particles remain separated from water after reverse osmosis, An ultra selective polyamide membrane was made during this study. Metal organic framework nanoflakes aligned horizontally at the water/hexane interface allowing for the retention of gas bubbles due to diamine monomers across the interface. These ultrathin crumpled nanofilms resulted in a higher desalination performance. *Notes aren't paraphrased-general blurbs on what happened -Reverse osmosis is currently the most utilized method of desalination, being highly effective at removing salt from seawater; some harmful particles are still permitted through these membranes. -Neutral particles that have small molecular masses tend to be the issue

	such as boron. - An ultra selective polyamide membrane was made during this study. This was done by strengthening the interfacial polymerization using nanoflakes that were amphiphilic metal organic for the framework. -The interfacial reaction zone is heated due to the way the nanoflakes line up horizontally at the hexane interface, allowing the diamine monomers to be sped up and so the gas bubbles would not be lost. -As a result, ultrathin polyamide nano film membranes were made that have a thickness of 5 nm, and their cross-linking degree ended up being 98 %. -These membranes ended up filtering out boron with around 90 % efficiency, being far more effective than typical membranes that are used in reverse osmosis. -This research article explains how they made the polyamide membrane filter out for specific toxins from seawater, and the results of this experiment with lots of detail. -The goal of this project is to find more effective ways of desalination, and this article gave the specifics of one method to do this.
Research Question/Problem/ Need	How can the polyamide membrane be modified so it filters more harmful particles than the standard reverse osmosis?

Important Figures	 -Figure 1-Illustrates the fabrication of polyamide membranes, including the nanoscale(nanoflakes), showing the thickness, electron and atomic force spectroscopy.

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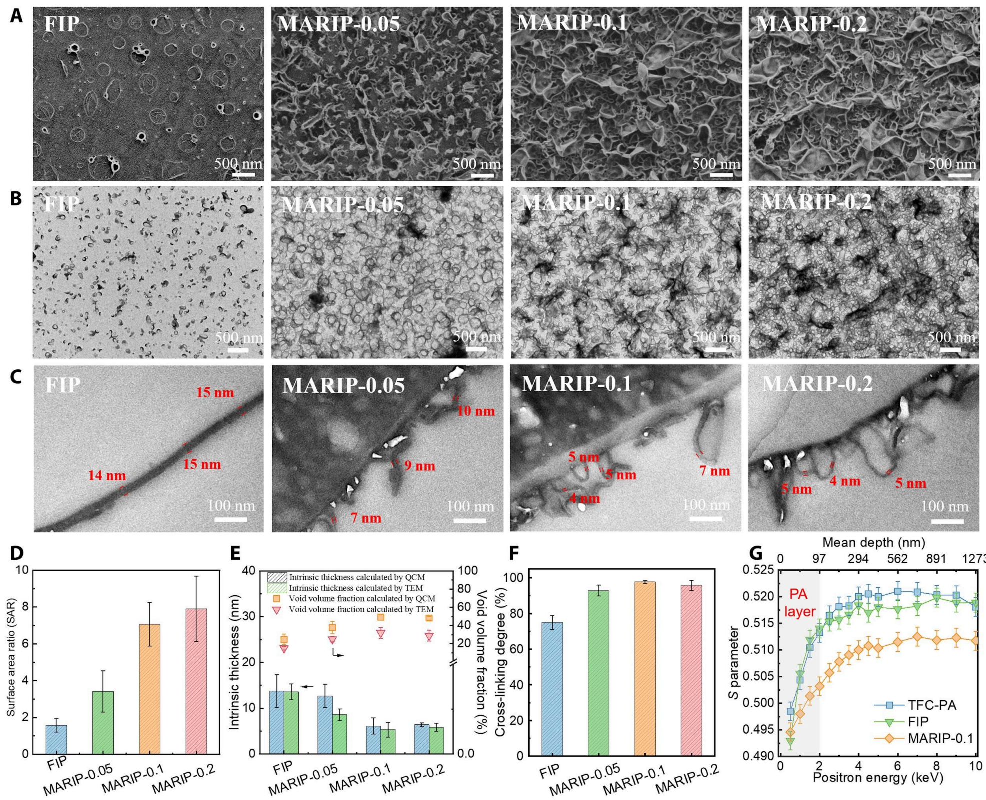

Figure 2- Micrographs analyzing the structure of the nanofilms from different angles.

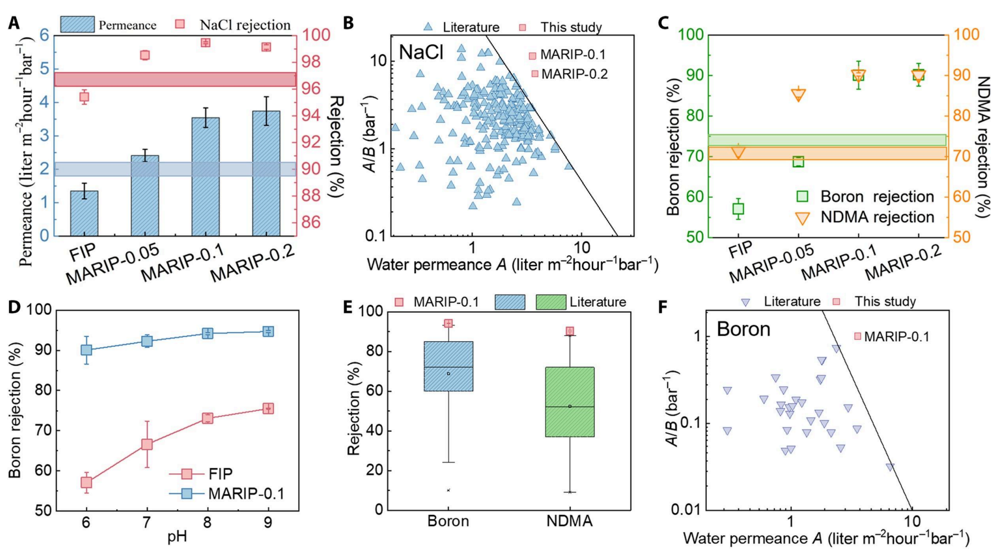

Figure 3-The results of how different membranes did rejecting NaCl, Boron, and NDMA (separating these things from water).

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<td>VOCAB: (w/definition)</td>
<td>Ultraselective polyamide membrane-a reverse osmosis filter allowing only certain constituents to pass through.</td>
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	Interfacial polymerization- Fabricates polyamide active layer, occurs between amine monomers. Amphiphilic metal- organic framework-metal framework whose molecules have both hydrophobic and hydrophilic areas. Diamine monomers-monomers in polyamide plastics-https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7657642/#:~:text=Diamines%20are%20important%20monomers%20for,6%2Ddiaminohexane%2C%20among%20others. Permselectivity-the capability of a membrane to filter out anions and cations-https://www.sciencedirect.com/topics/engineering/perm-selectivity#:~:text=Permselectivity%20is%20a%20measure%20of,separated%20by%20the%20test%20sample. Boron-harmful constituent in water (for the purpose of this article)-element on the periodic table and is a metalloid. *N*-nitrosodimethylamine-harmful constituent in water/carcinogenic (for the purpose of this article)
Cited references to follow up on	H. B. Park, J. Kamcev, L. M. Robeson, M. Elimelech, B. D. Freeman, Maximizing the right stuff: The trade-off between membrane permeability and selectivity. *Science* **356**, eaab0530 (2017). **CROSSREF** **PUBMED** **ISI** **GOOGLE SCHOLAR** **2** J. T. Mueller, S. Gasteyer, The widespread and unjust drinking water and clean water crisis in the United States. *Nat. Commun.* **12**, 3544 (2021). **GO TO REFERENCE** **CROSSREF** **PUBMED** **GOOGLE SCHOLAR** **3** M. Elimelech, W. A. Phillip, The future of seawater desalination: Energy, technology, and the environment. *Science* **333**, 712–717 (2011). **GO TO REFERENCE** **CROSSREF** **PUBMED** **ISI** **GOOGLE SCHOLAR** **4** C. Z. Liang, M. Askari, L. T. Choong, T.-S. Chung, Ultra-strong polymeric hollow fiber membranes for saline dewatering and desalination. *Nat. Commun.* **12**, 2338 (2021).
Follow up Questions	1. Is this new polyamide membrane also capable of filtering out other

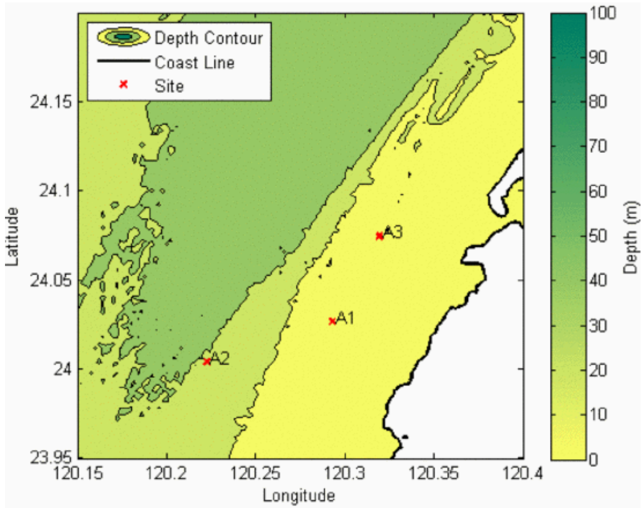
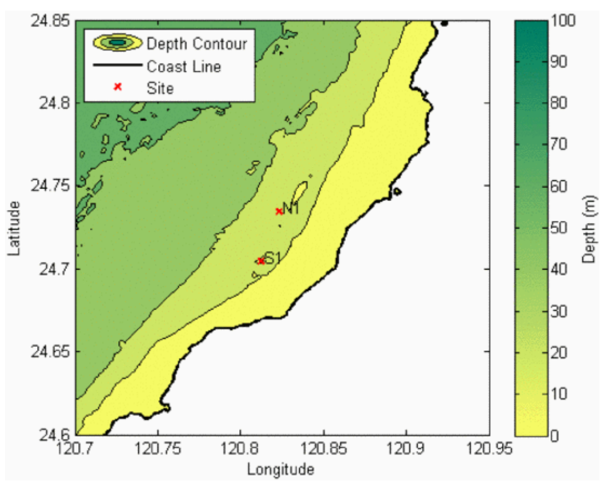
	harmful constituents? 2. How could these be improved to yield almost 100 % separation between harmful constituents and water instead of 90 %? 3. How does this new polyamide membrane change the amount of energy required, and how frequently does it get clogged costing money for maintenance? 4. How quickly does this new polyamide membrane deteriorate,-how much would it cost to continuously replace if it deteriorates quickly?

Article #6 Notes: Underwater noise measurement and simulation for offshore wind farm in Taiwan

Article notes should be on separate sheets

Source Title	Underwater noise measurement and simulation for offshore wind farm in Taiwan
Source citation (APA Format)	Wu, C.-H., Wang, W.-C., Hsu, Y.-S., Liu, D.-H., Chen, C.-F., Hu, W.-C., Chen, N.-C., Lin, S.-F., Hwang, W.-S., Huang, Y.-H., & Li, W.-L. (2017). Underwater noise measurement and simulation for offshore wind farm in Taiwan. *2017 IEEE Underwater Technology (UT)*, 1–7. https://doi.org/10.1109/UT.2017.7890320
Original URL	https://ieeexplore.ieee.org/document/7890320
Source type	Conference Paper
Keywords	Wind turbines, Taiwan, dolphins, noise, frequency
#Tags	Wind Turbines, Taiwan, dolphins, clean energy, green energy
Summary of key points + notes (include methodology)	Taiwan is supporting the “Thousand Wind Turbines” project, and is looking at the From 2013 to 2016, data on underwater sound was collected off of the west coast of Taiwan. The noise from Pile driving was around 100-300 Hz and the sound pressure level was 178 to 188 dB. A simulation was made to analyze what factors contribute to sound and sound absorption relating to its harm with aquatic animals. The distance and the type of sediment (clay vs. sand) had the greatest impact on the magnitude of the sound. *Notes aren’t paraphrased-general blurbs on what happened -Taiwan’s geographic location makes it optimal to implement wind energy.

	The Taiwan strait in particular is optimal for an offshore wind farm. -Offshore wind is more powerful than onshore wind. -Taiwan promotes the “Thousand Wind Turbines” project. -They seek to install 800 offshore, 450 onshore wind turbines before 2030. -This location is close to the Sousa chinensis (Indo-Pacific Humpback Dolphin/Chinese White Dolphin), a near threatened species. construction sounds have shown to harm these animals. -National Marine Fisheries Service-(NMFS)-sound pressure levels (SPLs) that cause physical harm-Level A (180 dB (rms)-190 (rms) for cetaceans and pinnipeds, harassment, behavioral disturbance=Level B harassment-120 and 160 rms. -The power spectral density (PSD) from the Marine Recorder Spectrogram was used. -An SM3M was used to measure pile driving noise170 and 230 meters from the sites in 18-20 meter deep water. -The source level is thought to be 230 dB re 1μPa, the piling was hit by the driver 72 times in two minutes. -Pile driving noise frequency-100-200 Hz, sound pressure maximum was 178 dB and 188 dB. -A simulation for a potential wind farm is made, water depth=20-30 m, sediments are clay and sand, energy of sound in simulation is 80-400 Hz. -Range-dependent Acoustic Model (RAM-PE) was used and calculated transmission loss from the frequency by the 12 azimuth angle, and Fourier synthesis was used to find what the time series was. -Water depth increases and clay lessens the impact from the noise. -Single frequency simulation from the underwater noise from 28 turbines off of Changhua was conducted. -Grater distance and clay help with sound absorption. -Energy decayed logarithmically, closer distance=bigger change in slope -Win turbines working simultaneously and SPLs are accumulated, max value=105-110dB and won’t affect dolphins and cetaceans.

Research Question/Problem/ Need	How can the installation of an offshore wind farm affect sound level and sound absorption so as to not harm aquatic life?
Important Figures	 Figure 1-This bathymetric map shows the different locations (A1, A2, and A3) in the changhua coast.  Figure 2-Shows where the N1 and S1 sites are.

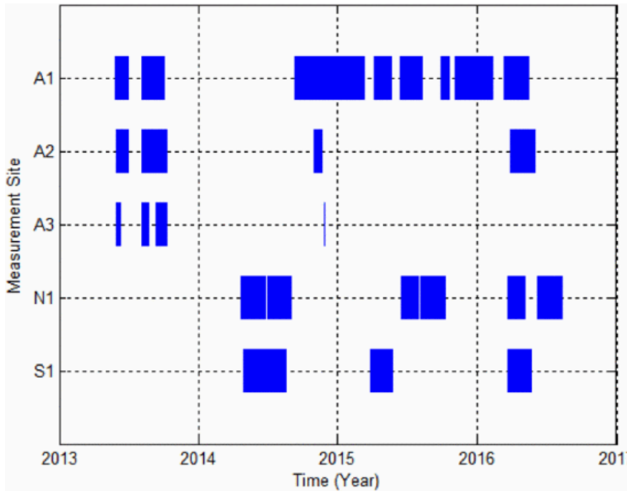


Figure 3

Gantt chart of the measurement days made in changhua and miaoli coasts from 2013 to 2016

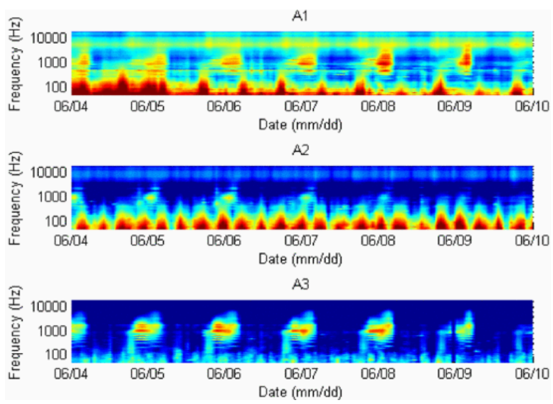


Figure 4

Spectrograms of site A1, A2 and A3 in changhua coast from 2013/06/04 to 2013/06/10

Year / Site	2013	2014	2015	2016	Total
A1	95	113	260	107	575
A2	102	23	0	66	191
A3	66	4	0	0	70
N1	0	132	112	112	356
S1	0	113	61	64	238

Table 1 Measurement days made in changhua and miaoli coasts from 2013

to 2016

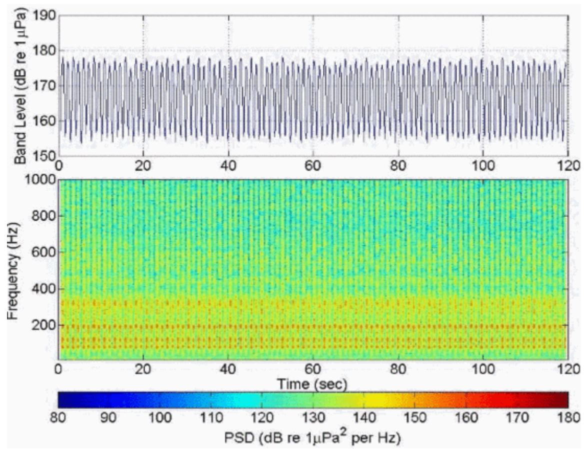


Figure 8

Pile driving noise: Site 1 (data time: 2016/9/3 21:02-21:04)

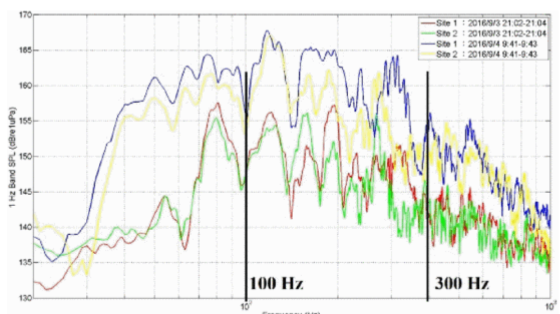


Figure 12

1-Hz band spectrum at site 1 and site 2

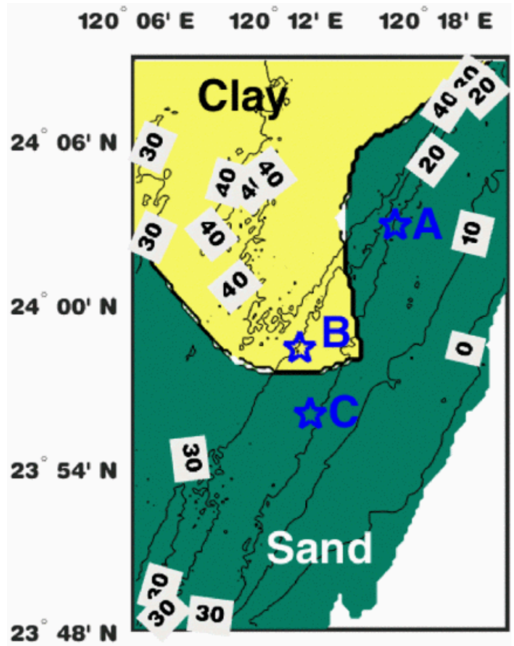


Figure 13

Location, sediment and water depth of the simulations. The sediment are the clay and the sand, and the water depth of simulation points is about 20~30 meters,

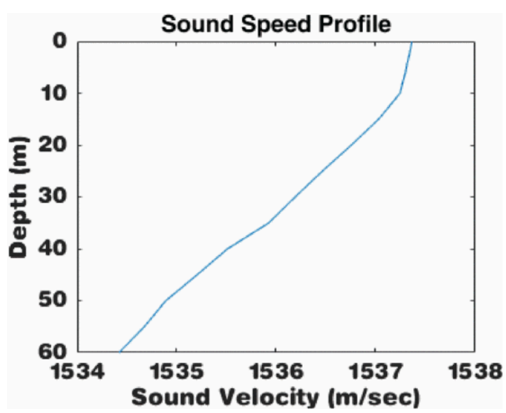


Figure 14

The sound speed profile using in the simulation. The sound speed decreases while getting depth.

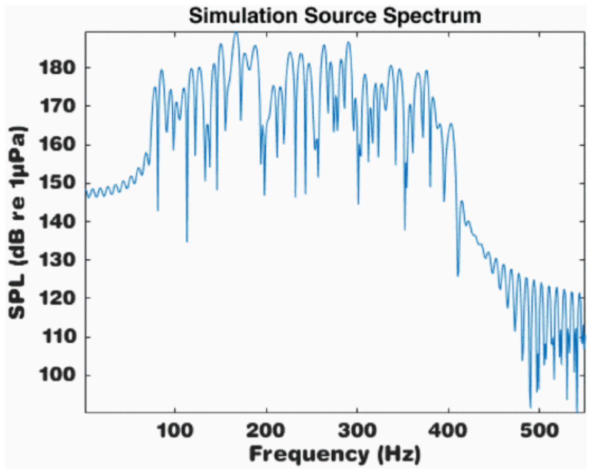


Figure 15

Simulation sound source spectrum. The energy is concentrated in the band of 80~400 Hz.

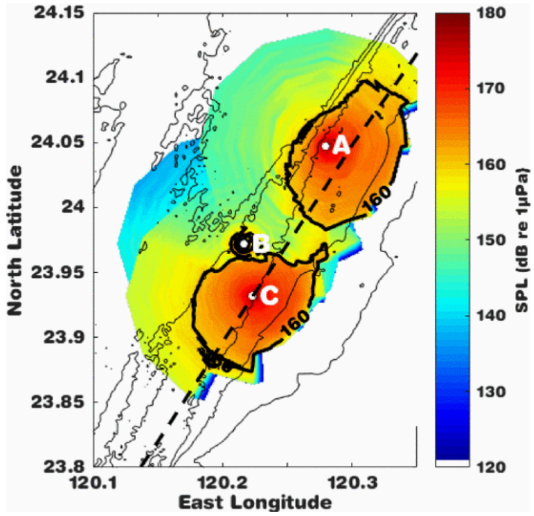


Figure 16

The simulation result. The bold line means the 160 dB SPL, and the dashed line means the boundary of the chinese white dolphin conservation area.

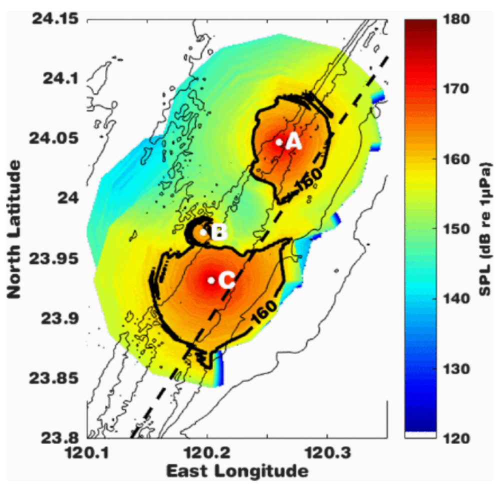


Figure 18

The simulation result. Moving all simulation points 2 km away in west direction.

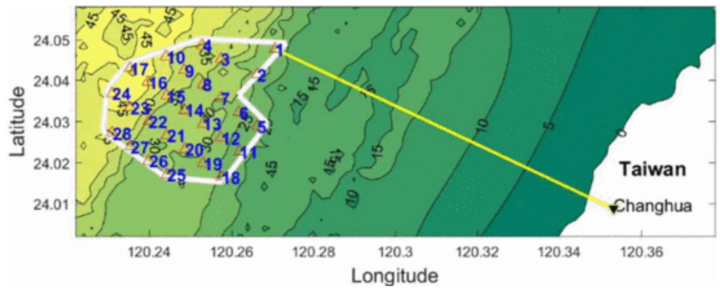


Figure 19

The location for 28 wind turbines with 4MW are in the offshore area of changhua in western taiwan.

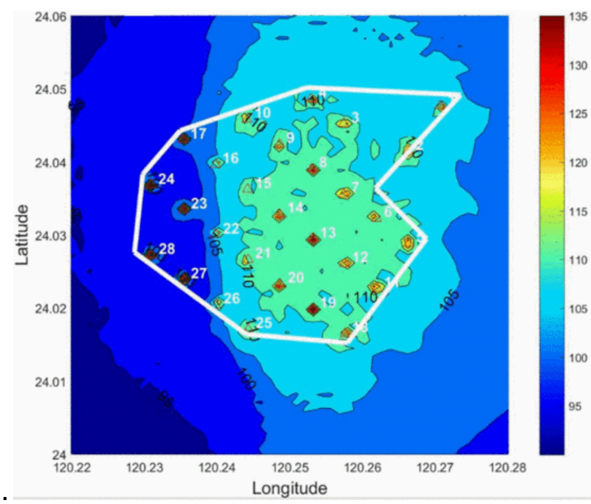


Figure 20

The simulation result of the SPLs accumulated between 28 wind turbines

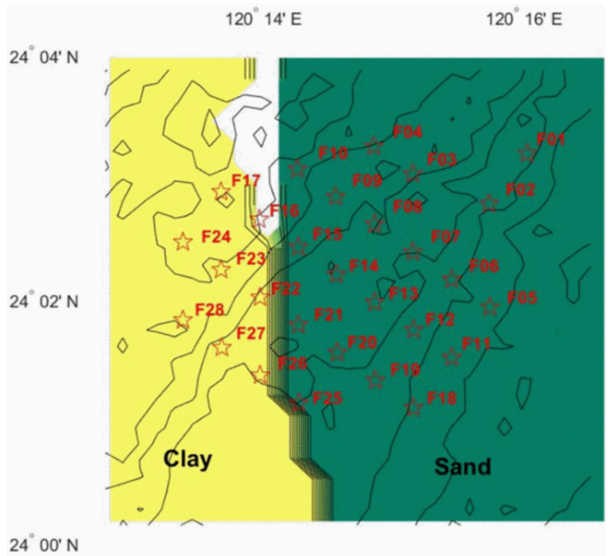


Figure 21

The distribution of the 28 wind turbines with different seabed sediments.

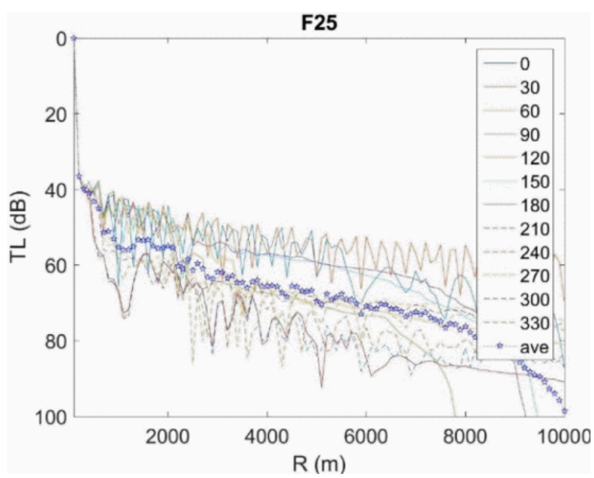


Figure 22

The 25th TL curve of the average and each 12 azimuth angles.

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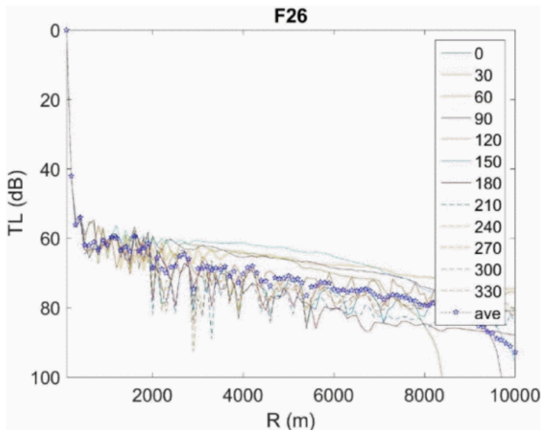

Figure 23

The 26th TL curve of the average and each 12 azimuth angles.

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<tr>
<td>VOCAB: (w/definition)</td>
<td>-Pile Driving-a machine that moves/drives piles in the ground.-Webster
-Sound pressure level-the difference between the instantaneous pressure at a point in the presence of a sound wave and the static pressure of the medium.-Oxford Languages
-Power Spectral Density-the measure of signal's power content versus frequency. -SIEMENS Community
Cetaceans-a marine mammal-dolphins, whales, porpoise-Oxford Languages
-Azimuth Angle-the angle between North, measured clockwise around the observer's horizon, and a celestial body (sun, moon).-PhotoPills
-Fourier Synthesis-a wave addition algorithm. -Cerritos College
-Monopile foundation-continuous cylindrical tube of constant diameter and wall thickness.-ScienceDirect</td>
</tr>
<tr>
<td>Cited references to follow up on</td>
<td>1.
F. Lauha, S. Steve, S. Sgruti and Q. Limig, "Global wind report annual</td>
</tr>
</table>

	market update 2013", *Global Wind Energy Council Brussels Belgium*, 2012. **2.** C. S. Associates, "Geological and Geophysical Exploration for Mineral Resources on the Gulf of Mexico Outer Continental Shelf: Final Programmatic Environmental Assessment: US Department of the Interior", *Minerals Management Service Gulf of Mexico OCS Region*, 2004. **3.** H. Team, "High Energy Seismic Survey review process and interim operational guidelines for marine surveys offshore Southern California. Rep. from High Energy Seismic Survey Team for Calif. State Lands Commis. and Minerals Manage. Serv. Camarillo CA. 39 p.+ Appendices", *Rep. from High Energy Seismic Survey Team for Calif. State Lands Commis. and Minerals Manage. Serv. Camarillo CA*, 1999. **4.** J. Gordon, D. Thompson, D. Gillespie, M. Lonergan, S. Calderan, B. Jaffey et al., "Assessment of the potential for acoustic deterrents to mitigate the impact on marine mammals of underwater noise arising from the construction of offshore windfarms", *Sea Mammal Research Unit report for Cowrie Ltd St Andrews*, 2007. **5.** M. D. Collins, "Users Guide for RAM Versions 1.0 and 1.0 p", *Naval Research Lab Washington DC*, vol. 20375, 1995. **6.** F. B. Jensen, W. A. Kuperman, M. B. Porter and H. Schmidt, *Computational ocean acoustics: Springer Science & Business Media*, 2011.
Follow up Questions	1. How do other sediments absorb sound compared to sand and clay? 2. How much energy is predicted to be lost due to the movement of the wind turbine farm? 3. Do the new frequencies of sound from the new turbines being built affect communication between these animals ? 4. Could any devices be used to trap the sound and/or reconvert it back into usable electricity, if so where would they be placed for optimal sound absorption?

Article #7 Notes: Underwater noise reduction of offshore wind turbine using compact circular liner

Article notes should be on separate sheets

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Source Title	Underwater noise reduction of offshore wind turbine using compact circular liner
Source citation (APA Format)	Zhou, T., & Guo, J. (2023). Underwater noise reduction of offshore wind turbine using compact circular liner. *Applied Energy*, *329*, 120271. https://doi.org/10.1016/j.apenergy.2022.120271
Original URL	https://www.sciencedirect.com/science/article/pii/S0306261922015288?via=ihub
Source type	Journal Article
Keywords	Circular liner, offshore wind turbine
#Tags	Circular liner,
Summary of key points + notes (include methodology)	Offshore wind turbines are being used more and more at optimized amounts to produce the greatest amount of energy. However, these turbines also generate lots of noise, having a variety of damaging effects on marine life. The prominent source of noise pollution relevant to underwater animals is mechanical noise, mainly from the nacelle. This study looked at how a circular liner could be used as a method of sound absorption, using a three-dimensional analysis of acoustic performance from the FE simulation software from COMSOL Multiphysics. In order to analyze the effect of the liner on the tower, the finite element method was used. The liner was shown to reduce the noise given off by around 18 dB, and caused the radiation angle of the wave front to decrease because the speed of sound in water is greater than in the liner. -*Notes aren't paraphrased-general blurbs on what happened Offshore wind farms are continuously growing in use, however they produce lots of sound that harm marine life. -Due to the sound effect on marine life, it is a pollutant, and is connected to wildlife legislation. -The effects on marine animals vary based on the noise and animals, and studies have tested the effects of these wind turbines on different fish and mammal species. -sound from these turbines can cause hearing problems, scare animals, cause discrepancies in communication, and may lead to avoidance or physiological damage.

	-The two predominant sources of sound from turbines are the aerodynamic noise emitted from the blades and the mechanical noise emitted from the nacelle. -Sound is transmitted to the water through air-borne paths, water-borne paths, and seabed-bourne paths. -Little from the air enters the water, so sound emission underwater comes from the mechanical components, mainly through the water-borne path. -Low frequency (below 2000 Hz), noise level=wind speed, type of foundation, and disk diameter. -Decay of underwater sound is found using the relationship between sound wavelength and distance, and the decrease of sound pressure following the Inverse Square Law. -Underwater noise simulated through finite element code. Compared to offshore measurements-good feasibility. -Hydro sound dampener-reduces underwater sound from offshore wind turbines, made from nets with air filled elastic balloons and PE-foam elements with high dissipation effects. -20 dB noise reduction. -Different foundations affect the amount of sound transmitted. -Gas-filled cavities and inclusions make monopole and dipole resonance: by arranging these-sound absorption. -Sound absorption=oscillation of the cover layer and radial motion of cavity walls. -Axial holes (conical and horn) holes replace cylindrical activity, making impedance roughly the same as water lowering sound reflection, while inclined walls enhance wave reflection scattering in the cavity. -Acoustic behavior may be looked at using the transferred matrix method, -Few noise reduction methods have been made, made using published measurement data, effects of the liner are looked at using the Acoustic-Solid Interaction module in COMSOL on a 3d pile-water model. -3.6 MW offshore wind turbines, Siemens SWT-3.6-107 used as prototypes, -Per unit of lined layer configuration, they made an analytical prediction model assessing its absorption capability, -Liner parts-front rubber, circular truncated cone + cylinder of middle region

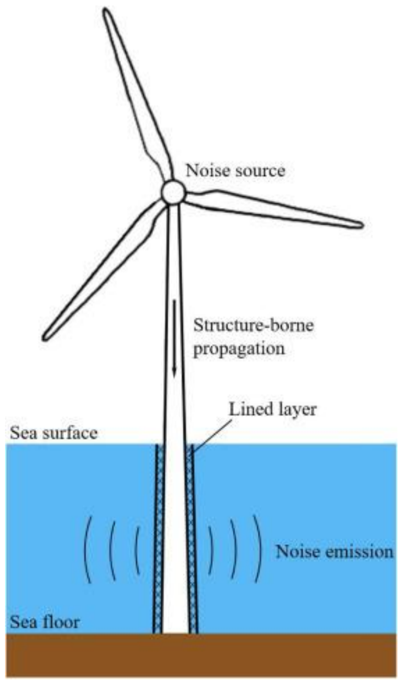
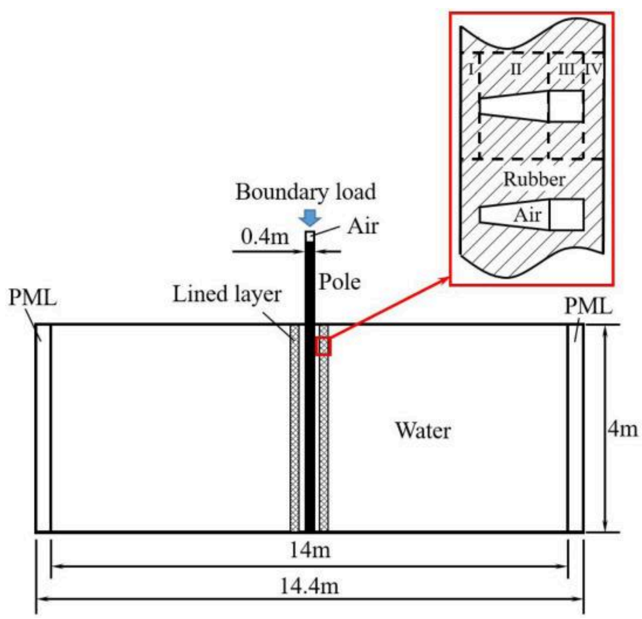
	with air-filled cavities, rear rubber region,
Research Question/Problem/ Need	How does a compact circular liner reduce the amount of sound produced underwater from offshore wind turbines?
Important Figures	 Figure 1: Diagram of an offshore wind turbine, including the lined layer, connecting it to the amount of sound given off into the water. 

Figure 2: Drawing of the Finite Element model, including the perfectly matched layer (PMLs), pile, water, sediment, and pole.

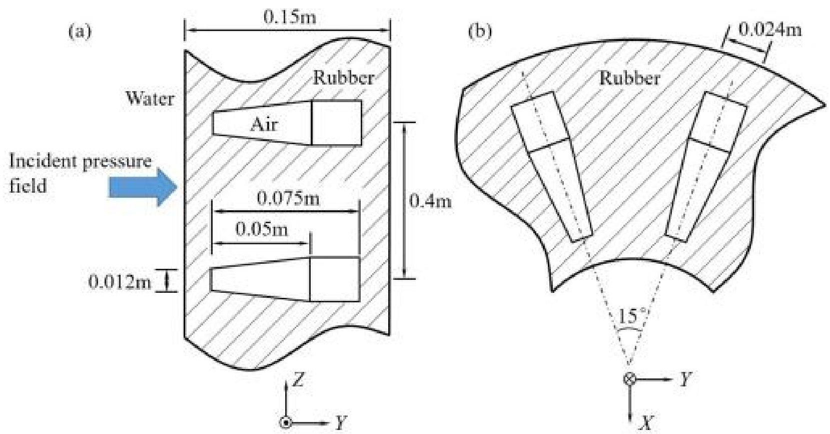


Figure 3: A Drawing of the top view of the lined layer.

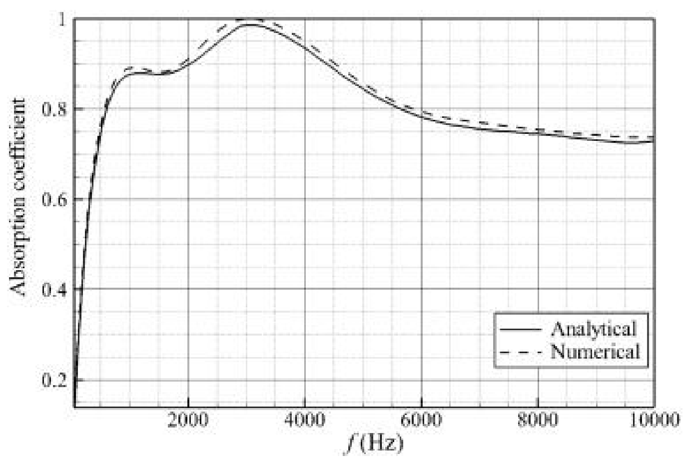
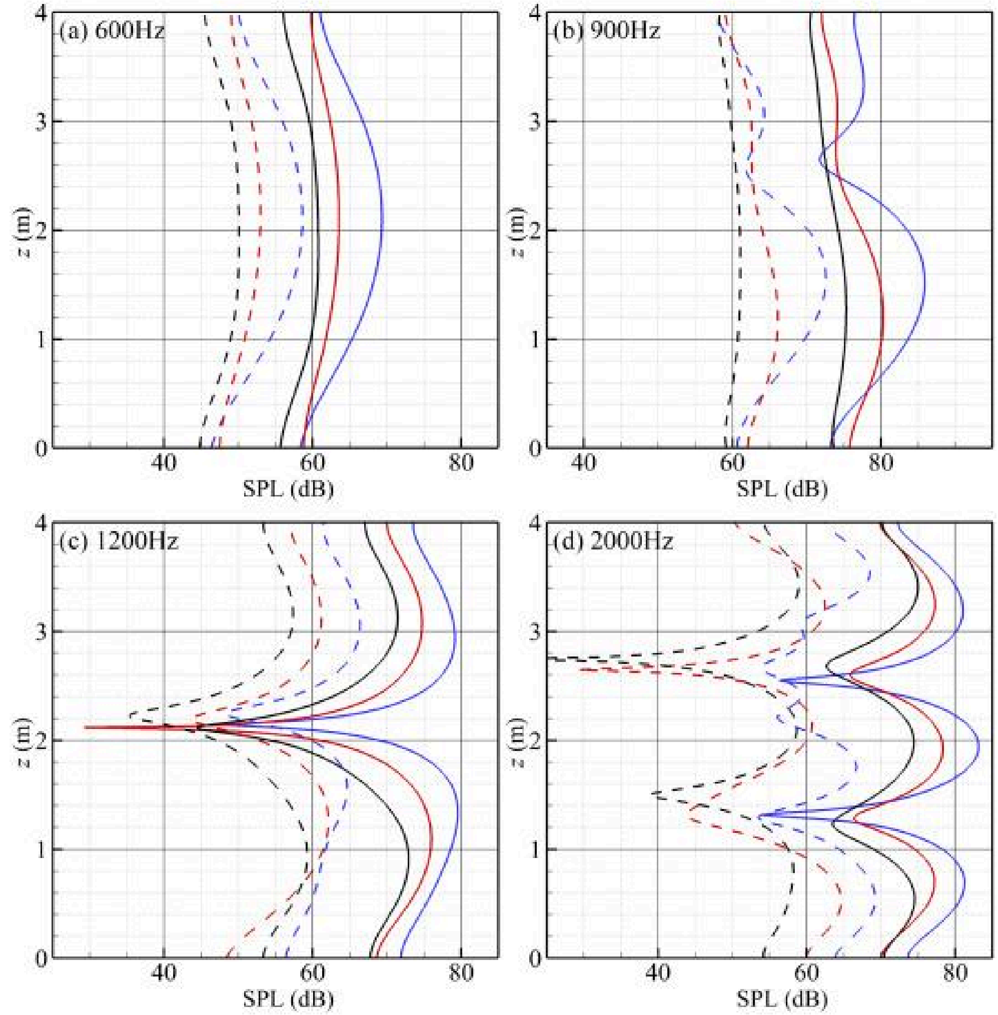


Figure 4: The sound absorption coefficient curve, this curve is based on the optimal liner designed.

	 Fig. 7. Dependence of SPL on water depth at various distances to the pillar. Blue lines: m. Red lines: m. Black lines: m. Solid lines: baseline model. Dashed lines: lined model.
VOCAB: (w/definition)	-Offshore wind turbines-a wind turbine located off the coast in the ocean, are growing in use due to their optimal placement in terms of wind. -aerodynamic noise-noise produced from the blades of a wind turbine. -noise attenuation-amount of noise culminated. -energy dissipation-the amount of energy lost to heat. https://phys.libretexts.org/Bookshelves/Electricity_and_Magnetism/Electricity_and_Magnetism_(Tatum)/04%3A_Batteries_Resistors_and_Ohm%27s_Law/4.06%3A_Dissipation_of_Energy -radial displacement-the offset in a radial direction/a change in direction of a radius by a certain number of degrees. https://www.sciencedirect.com/topics/engineering/radial-displacement -Finite Element Simulation-defined using partial differential equations, these

	explain things such as mechanical deformations, thermal diffusion, the interaction of flowing fluid, etc. -Renewable and Sustainable Energy Reviews, 2021 Propagation Direction-Polarization is one of the most important and intrinsic characteristics of light, which refers to the asymmetry between the vibration direction and propagation direction of light.-Nano Today, 2020
Cited references to follow up on	E. Parliament, Council, directive 2008/2056/ec of the European parliament and of the council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy, Marine strategy framework directive (2008) COUNCIL G.W. Global wind report: annual market update Global Wind Energy Council (2015) Wahlberg M., Westerberg H. Hearing in fish and their reactions to sounds from offshore wind farms Mar Ecol Prog Ser, 288 (2005), pp. 295-309 Thomsen F., Lüdemann K., Kafemann R., Piper W. Effects of offshore wind farm noise on marine mammals and fish, Biola, Hamburg Germany on Behalf of COWRIE Ltd (2006), p. 62
Follow up Questions	1. How would this noise reduction liner be affected by different conditions, such as extreme temperatures? 2. Could an optimal design be applied and tested to offshore wind turbines, and how would its effect on marine life be tested? 3. How might this liner and arrangement change with different bases/foundations? Could a model be developed to do this? 4. The transmissions of sound through the wind turbine to the foundation was said to have caused seismic waves in the seabed, could these seismic waves also be generated by wind turbines on land? How might this affect local wildlife, and how would the liner

	change if it worked at all to be used on land?

Article #8 Notes: Effects of land-based wind turbine upsizing on community sound levels and power and energy density

Article notes should be on separate sheets

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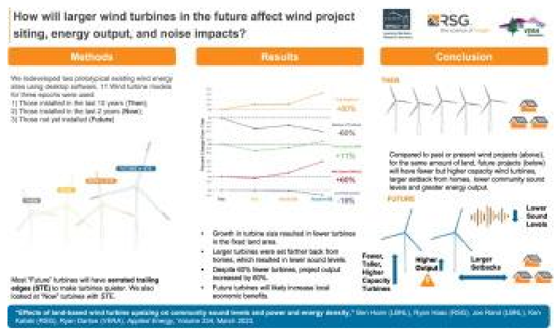
Source Title	Effects of land-based wind turbine wind turbine upsizing on community sound levels and power and energy density
Source citation (APA Format)	Hoen, B., Darlow, R., Haac, R., Rand, J., & Kaliski, K. (2023). Effects of land-based wind turbine upsizing on community sound levels and power and energy density. *Applied Energy*, *338*, 120856. https://doi.org/10.1016/j.apenergy.2023.120856
Original URL	https://doi.org/10.1016/j.apenergy.2023.120856
Source type	Journal Article
Keywords	Wind energy, Wind turbine scaling, Energy density, Community impacts, Land use, Distributive justice
#Tags	Wind turbine scaling, Land use
Summary of key points + notes (include methodology)	Wind turbines are increasing in size to yield greater efficiency and greater output of energy. However, as the wind turbines increase in size along with their rotor diameters, they become louder and louder. Different factors include turbine scaling, efficiency, market dynamics, transmission and interconnection constraints, land use, and social acceptance are all varying factors, making predictions based on past tendencies unreliable. In this

	study, the amount of energy produced, noise in nearby communities, and the planning of wind turbine sites due to their predicted increase in size. This study used WindFarmer software to model two sites, and used three different types of wind turbines, each representing a different era of wind turbine models. The greatest number of wind turbines were implemented in this model, therefore also maximizing the power output. Newer wind turbines produce more sound and so have to be moved farther from residential areas, fewer total wind turbines can be installed in given areas. This study found that more average energy would be produced, and windmill sound pollution in nearby areas would decrease. This model also predicts that there would be correlating economic benefits as well. *Notes aren't paraphrased-general blurbs on what happened -Many countries are trying to turn away from carbon based electricity and towards land based wind energy. -Certain factors control the locations and how these will be implemented, these are turbine scaling, turbine-and plant-level efficiencies, Market dynamics, Transmission and interconnection constraints, Land use, and social acceptance. -These factors need to be understood to give a clear direction to people as to where wind energy is going as trends from the past won't correlate to the future because of these constantly changing factors. -Wind turbine height has increased over the last two decades, and the increase of rotor diameter has decreased specific power correlating to an increase in output of energy. -The larger the wind turbine, the less there can be in a given area. -Wind turbine sound emissions have increased-partially due to longer blades-faster speed of tips. -Rotation speed can be decreased to decrease tip speed and lower sound emitted, but not enough. -Sound pressure levels and SWL aren't the same. This is influenced by wind speed, the topography, and other factors. -As the SPL increases, they move farther from areas giving them room for more. -Residents dislike wind turbine sounds, so blades with serrated turbine edges-serrations on the airfoil edge to decrease the amount of turbulence-reduce sound given off and (theoretically don't affect energy output)

	-Some studies show taller turbines that don't have as large of specific power ratings make the land-based wind power potential higher. -Not much is known about future land-based wind turbines and their effect on layouts, the generation of energy, the use of land, and the impacts of society. -How do expected wind turbine heights, rotor diameters, rated capacities, power curves, sound power levels affect the total installed capacity, annual energy generation, land use, financial benefits. Methods: -Desktop software was used to site the projects, two wind development prototype sites, three wind turbine models representing three time periods, number of wind turbines installed was maximized-total power output also maximized. Site selection -midwest, shared characteristics-developable area, parcels, wind direction, Receiver data -From Melissa Data, Microsoft's Bing Maps footprint layer, Corelogic data-all homes in 2k radius of wind turbines Wind turbine data -Structural, operational, sound characteristic data-US Wind Turbine Database, Wind Pro(operational power curve, thrust curve, sound curve)-missing data from manufacturer Manufacturers and epochs General Electric, Siemens Gamesa, Vestas, three turbines were looked at, Then-2011-2020, now-2019-2020, future-2023-2025, -Focused on sound from turbines, want to determine how SPL changes at homes around wind projects as those projects grow. (serrated trailing edge-minimal theoretically positive power output) -Average total height 122m-202m, capacity 1.8MW to 5.0MW, specific power 324W/m^2-257W/m^2, mean sound levels 104.3 dBA to 105.3 dBA-107.7 dBA-STE decreased by 1.6 dB Wind resource

	11 turbine models, 2 sites-wind resource grid calculated at hub heights 80m, 85 m, 90 m, 95 m, 115 m, 115 m, 125 m, 132 m , with WAsP software to give 16 wind direction sectors, -Meteorology data from Wind Toolkit 2007-2013, wind speed at different heights, and hourly wind direction, -Elevation surface roughness WAsp, National Elevation Dataset Digital Elevation Model , 2011 11 National Landcover Dataset, Model basis- data was put into WindFarmer, turbine specifications plus operation performance were added, -gave hourly wind energy production-annual wind energy production, -Boundary setback, maximum sound levels, elliptical spacing 8 rotor diameters, -Layouts were optimized for the production of energy -SPL limits 45 dBA non-participating residents, 50 for participating, SPI measured in decibels (logarithmic) -time averaged octave band sound levels converted to loudness using calculation -Wind turbine heights increase 60 % 122m to 202m, sound power level increases, fewer number of turbines can be developed, average number going down 60% (222-89), increased capacity by 11% (395 MW to 437 MW), the predicted annual energy output increases by 60%. -Sound pressure levels decreased for everyone. -lower SPL limit, less turbines being installed-better for environment, -Higher tax, could cause distributive injustice due to fewer landowners
Research Question/Problem/ Need	How will bigger wind turbines affect the amount of energy produced, the planning of wind turbines, and the amount of noise both generated and present in nearby communities?

Important Figures



Graphical Abstract-This gives a visual representation of the experiment. It labels the methods, results, and conclusion.

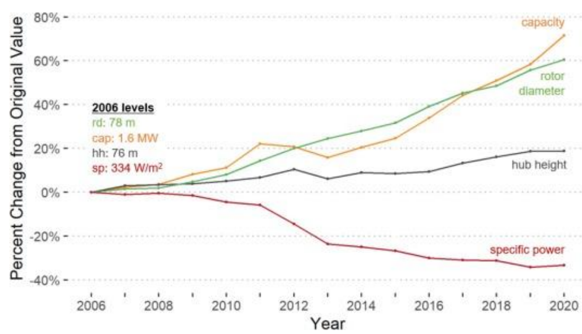


Fig. 1.

The annual wind turbine rotor diameter, capacity, hub height, and specific power percentage throughout different amounts of time in the US.

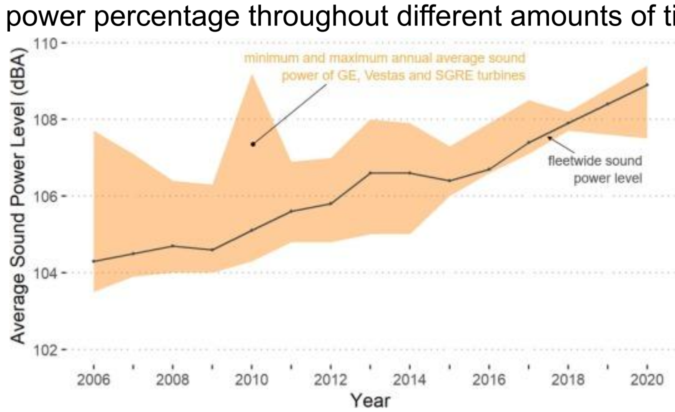


Figure 2
The annual averages, minimum and maximums of US sound power levels for General electric, Vestas, and Siemens wind turbines.

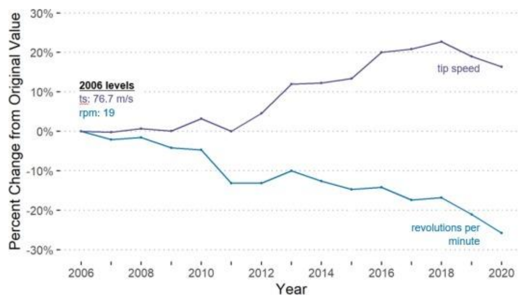


Figure 3-Average wind turbine tip speeds and rotations per minute for US turbines.

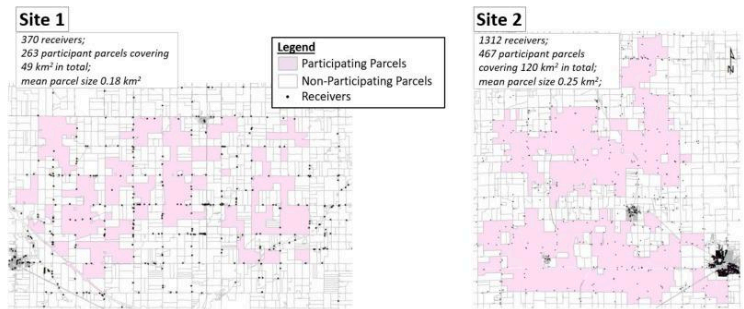


Figure 4-Maps of site one and site 2, pink representing participating areas, while white represents non-participating areas.

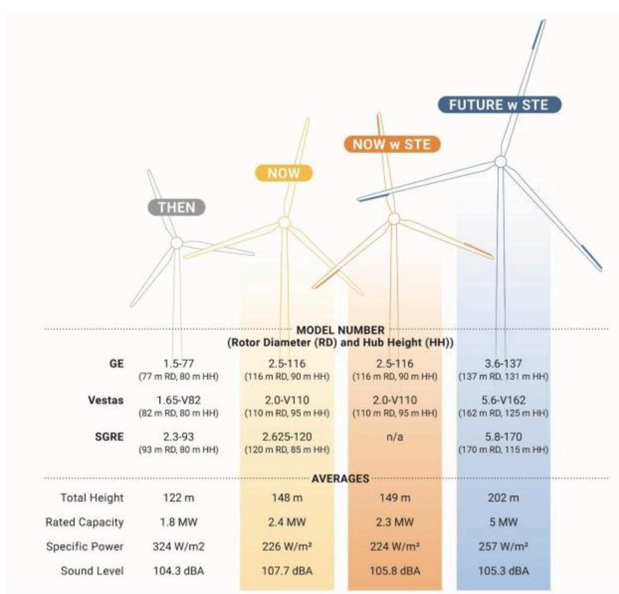


Fig. 5. Then, Now, Now with STE, and Future with STE wind turbine models for each manufacturer. Sound level refers to SWL.

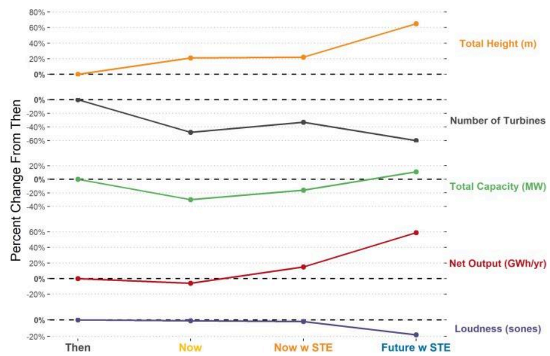


Fig. 6. Mean total wind turbine height, numbers of wind turbines, total project capacity, project output, and loudness among Then to Future w STE wind projects.

VOCAB: (w/definition)

-Turbine scaling—the continuous growth in turbine height, rotor diameter, and capacity;
-Turbine- and plant-level efficiencies—the consistent increase in wind project capacity factors;•

-Market dynamics—e.g., changes to the levelized cost, and grid-system value of wind energy;

-Transmission and interconnection constraints—the ability to connect and transmit large amounts of wind power via the bulk transmission system; •

-Land use—the need to find viable land for wind energy build-out;

-Social acceptance—the acceptance and approval of wind projects by local community members and permitting authorities.

-nameplate capacity-maximum rated electrical power output

-specific power-rated power output per unit of rotor swept area

-Sound pressure levels-the amount of sound measured at receiver locations

	such as homes or property lines near a wind project. -serrated trailing edges-on the trailing edge of airfoil blades to reduce turbulent airflow.
Cited references to follow up on	1. Net Zero by 2050 - A Roadmap for the Global Energy Sector. 224. Google Scholar 2. The White House. President Biden Sets 2030 Greenhouse Gas Pollution Reduction Target Aimed at Creating Good-Paying Union Jobs and Securing U.S. Leadership on Clean Energy Technologies. *The White House*https://www.whitehouse.gov/briefing-room/statements-releases/2021/04/22/fact-sheet-president-biden-sets-2030-greenhouse-gas-pollution-reduction-target-aimed-at-creating-good-paying-union-jobs-and-securing-u-s-leadership-on-clean-energy-technologies/ (2021). Google Scholar 3. IRENA. *Future of wind*. https://www.irena.org/publications/2019/Oct/Future-of-wind. Google Scholar 4. E. Larson, *et al.* Net-Zero America: Potential Pathways Infrastructure, and Impacts, interim report (2020) Google Scholar 5. M. Bolinger, *et al.* Opportunities for and challenges to further reductions in the “specific power” rating of wind turbines installed in the United States Wind Eng, 45 (2021), pp. 351-368
Follow up Questions	1. How could the sound levels change in different topographical environments, as well as areas with different climates than the MidWest? 2. Could serrated trailing edges be further optimized to decrease the sound production while increasing the energy production? 3. How could electrical interconnection constraints affect the strategy

	used in this article? 4. How do individual contributions of sound level setbacks compare to total height related setbacks?

Article #9 Notes: Bio-Inspired Aerodynamic Noise Control: A Bibliographic Review

Article notes should be on separate sheets

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Source Title	Bio-Inspired Aerodynamic Noise Control: A Bibliographic Review
Source citation (APA Format)	Wang, Y., Zhao, K., Lu, X.-Y., Song, Y.-B., & Bennett, G. J. (2019). Bio-Inspired Aerodynamic Noise Control: A Bibliographic Review. *Applied Sciences*, *9*(11), 2224. https://doi.org/10.3390/app9112224
Original URL	https://www.mdpi.com/2076-3417/9/11/2224
Source type	Journal Article
Keywords	biionics; aerodynamic noise control; leading edge serrations; trailing edge serrations; fringe-type trailing edge; porous material
#Tags	Leading edge serrations, fringe-type trailing
Summary of key points + notes (include methodology)	Owls have the ability to fly silently, making them an ideal model for airfoil noise reduction. This bibliographic review has therefore gone through and collected the main findings of various studies, and organized them in a cohesive way. The macroscopic aspects as well as the microscopic aspects were looked at. These studies tested the noise reduction from actual birds, wings in wind tunnels, as well as theoretical methods of noise reduction based on different aerodynamic concepts. The silence of an owl's wings is a result of leading edge serrations, trailing edge fringes, and smooth texture. These aspects have contributed to several different noise reduction methods, mainly being leading edge serrations, trailing edge serrations, fringe related tips, and porous surfaces.

	*Notes not paraphrased-general blurbs on what happened. -The noise produced by airfoils is becoming more and more of a problem. -Aircraft are growing in use, therefore increasing the noise produced by their wings/airfoils. -The use of wind power is also being used more and more, with the increased rotor diameter and these wind farms being located closer and closer to communities, the noise generated is becoming more and more of a problem. -Over the years,many strategies and devices have been made to try and lower the amount of noise produced by airfoils, being passive techniques. -Bionics look into the structure, function, and working principles of biological systems and try to utilize these natural phenomena and implement them into technology. -Aircraft were inspired by birds. Owls have been found to fly very quietly. -Owls have three main features allowing them to fly quietly, being serrated feathers on leading edges, fringes on trailing edges, and a soft coating on wings and legs. -Owls can hear prey that produce sounds in the range of 2-20 kHz, but owls only generate noise 2kHz and lower. -The noise produced by a mallard duck and tawny owl was compared in one study, with the suck producing much more noise. It was found that this was a result of its low flight speed and evolved plumage. -3D sound maps showed that sources of noise were distributed along the wing of an owl. -Leading edge serrations, soft fringes, fluffy down-like lower surface and velvety lower surface on owls wings-cause of low sound emission. -Study found that if leading edge serrations ad trailing edge fringes were removed, owls produced as much noise as other birds. -Roughly 20 million years ago owls evolved so they could fly silently. -Compared to a pigeon, barn owls feathers are longer, ave lesser radiates, longer pennula,-larger wingspan and wing cord, -wider wing area lower unit wing loading. -Leading edge serrations slowly slow down airflow -resulting is smoother

	local pressure gradients, lowering sound emitted. -Trailing edges fringes cause upper and lower airflow to partially mix, so some noise-producing vortices aren't produced. -The feathers being fluffy reduced the friction between feathers reducing noise. -Found that leading edge serration helps with noise reduction because it creates laminar flow/eliminates turbulence. -In another study, it was found that leading edge serrations behave like vortex sheet generators, compliant surfaces cause the frequencies to be lower, and the pores in owls wings makes the chordwise boundary layer thicker, lowering trailing edge noise. -leading-edge serrations effect of the flow field are dependent on flow conditions like the angle of attack. -Silence was accompanied by poor-flight -Leading edge serrations-split into saw tooth serrations and sinusoidal serrations. -laminar boundary-layer wake vortex shedding-removed tones -Results form another study found leading edge serrations could reduce rotational noise and vortex noise under certain conditions -Saw tooth serrations effectiveness were largely dependent on geometry and location of serrations, inflow speed, angle of attack, profile shape, etc. -Found that smaller serrations and serrations that had space between prongs worked better than larger serrations and ones that didn't have spacing. -How well it worked was dependent on blade pitch angle and rotor speed, and best noise reduction occurred by the stagnation point, and worked better at lower rotor tip speeds, also decreased when the angles of attack were high. -sinusoidal serrations/tubercies-flipper of humpback whale, leading edge serrations lowered tonal noise -saw tooth was more effective than sinusoidal with same wavelength and amplitude for serrations -good lamina instability tonal noise reduction can be made by sinusoidal

	leading edge serrations that have smaller wavelengths and larger amplitudes. -There isn't one optimal serration that fits all of the parameters -Geometries of leading edge serrations are divided into two categories: control of noise radiation, and of the source of noise. -Slitted V root serrations lowered the difference in pressure and vortex strength increasing the noise attenuation that occurred at low frequencies. Also helped get rid of negative noise reductions at high-frequencies. -Studies have shown leading edge serrations-better stall performance-letter lift, less drag, -could suppress stall on rotor/blades -Sawtooth serrations-vortex and rotational noise decreased, but efficiency also decreased. -questionable -Serration size was important for 2d wind tunnel model, little effect for serration lean (spanwise cant angle) -smaller sawtooth serrations when attached correctly to leading edge increased lift, made stream wise counter-rotating vortices re-energizing the boundary layer, decreasing airfoil wake thickness. -Larger serrations decreased lift. -Low angle of attack didn't affect drag, was smaller at higher angles of attack. -Serration location is important-closest to stagnation point region=more lift. -sinusoidal serrations lowered fluctuating lift and drag. -Serrations with higher amplitudes had less pressure at roots and more variation in pressure. -Sinusoidal serrations on whale flipper -lower drag coefficient, -Noise-reduction methods typically include creation of stream wise vortices and reduced span wise correlation. -One study, authors suggested leading edge serrations worked as cortex generators, -reducing vortex noise. -Might create counter-rotating stream wise vortex pairs at roots, causing the laminar boundary layer to "bypass transition"-reducing (T-S) instability

	waves, wrecking the acoustic feedback loop. -Pressure distribution-almost identical away from leading edge region, but different at leading-edge serrations area -Pressure signals that originated in different places caused large phase shifts, and also reduced span wise correlation-could reduce interaction noise radiation efficiency. -Serrations-when used on trailing edge of blades/airfoils-reduce broadband self-noise and instability tonal noise. -Greater noise reduction can come as a result of narrower, and sharper serrations. -Serration misalignment in terms of flow direction and chord plane caused an increase in noise. -Serrated blade for a wind turbine was quieter going down, but louder going up. -Added slits in saw tooth serrations created larger reduction of sound-distributed pressure between suction side-introduced permeability reducing intensity of the cross flow -mean pressure difference between suction and pressure sides of trailing edge ended up resulting in a less efficient scattering source. -Flow was on suction and pressure sides, lowering broadband noise and tonal noise -sawtooth geometry that was specified ended up lowering span wise coherence -high frequency noise increase is thought to be caused by cross flow through the roots between adjacent teeth. -Pressure side instability-shown to have caused instability noise -One study found that trailing edge serrations didn't change stream wise gradient, but caused a bypass transition of laminar boundary layer-turbulence-resulted in reduced amplitude and tonality of radiated sound. -Multiple studies found that common factors contributed to the success of trailing edge serrations, being instability tonal noise attenuation when flow speeds increased when the serrations were lowered with increasing flow speeds when skinny flat plate inserts were created, noise reduction was

	better at a larger angle of attack, when the amplitude and wavelength ration was the same the greater amplitude created less instability noise. -Studies showed that aerodynamic performance of tailing edge serrations were reliant on the flow speed, applied model, angle of attack, and geometrical aspects. -fringe type trailing edge extensions are modeled after primary feathers of different owl species. -Fringe-type trailing edge apparati caused a large reduction of broadband turbulent boundary layer trailing edge noise and narrow-band vortex shredding noise. -Many studies found that noise reduction characteristics of brush/slit configurations were correlated more closely with geometric aspects rather than flow conditions. -One experiment showed that cross vortex reduced the lift coefficient while increasing the drag coefficient. -Noise reduction of fringe-type trailing edge extensions is caused by smooth brush devices, automatically aligned brush extensions with the trailing edge flow, flow permeable extensions, and a transformation of span wise vorticity to stream wise vorticity because of brush extensions. -Soft and elastic downy upper surface of the wings and legs of owls are similar to an increase in air permeability in terms of sound generation. -In one study, a highly porous trailing edge that had the last 25 percent of the chord replaced with 20 percent density foam-metal nickel. -Porous materials were studied many different times, and were found to overall reduce the amount of sound generated, specifically broadband sound, but at higher frequencies they increased the amount of sound. -Porous materials were shown to have created left lift but more drag. -Sound reduction via porous is influenced by oscillatory fluid passing through, the communication of the flow on the pressure side, suction side, and the back of the boundary layer, the spatial correlation length of pressure fluctuations, and edge impedance.

<table>
<tr><td></td><td></td></tr>
<tr><td>Research Question/Problem/ Need</td><td>Why don’t owls generate lots of noise when they fly, and how can this be applied to different airfoils?</td></tr>
<tr><td>Important Figures</td><td>

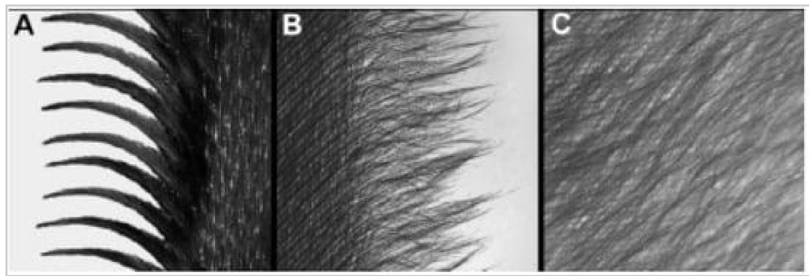

Figure 1. Figure one shows the adaptations of a barn owl, including leading edge serrations, trailing edge fringes, and its soft coat.

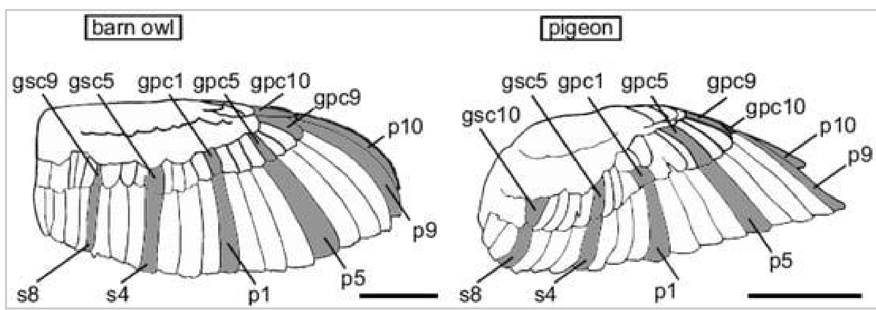

Figure 3: Depicts the feather structure of a barn owl vs. a pigeon.

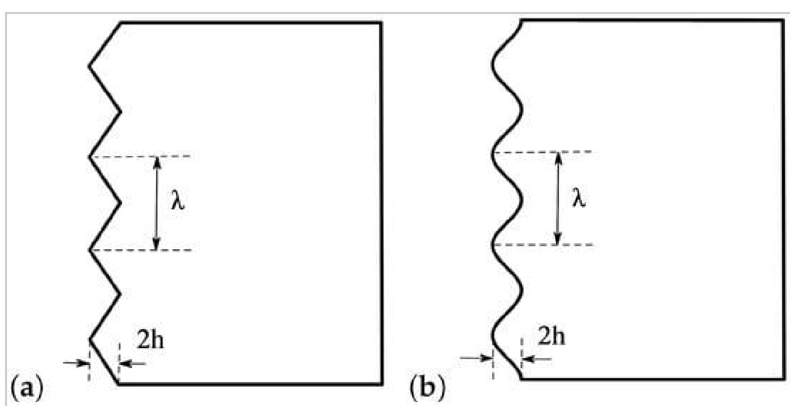

Figure 4: shows leading edge serrations in terms of wavelength and amplitude, b is a sinusoidal serration, a is a sawtooth serration.

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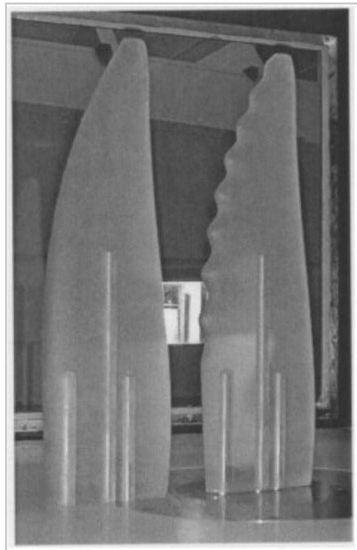

Figure 7: Humpback whale flippers with and without sinusoidal serrations.

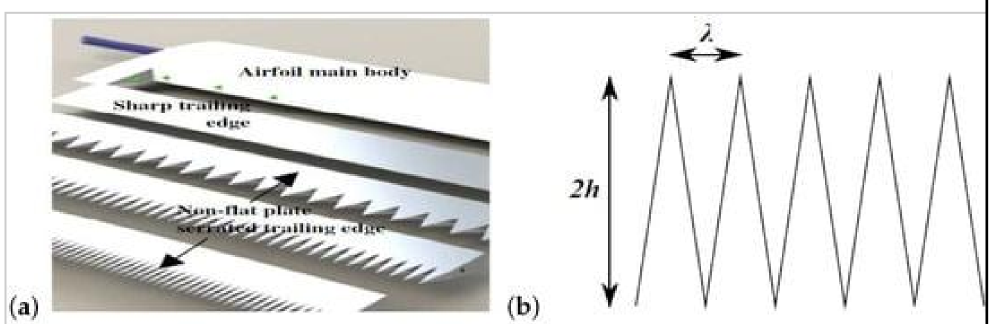

Figure 9. Trailing edge serrations- CAD drawing of the NACA 0012 airfoil model with one sharp trailing edge and three non-flat plate serrated trailing edges (**b**) sketch of the trailing edge serrations with definition of wavelength and amplitude.

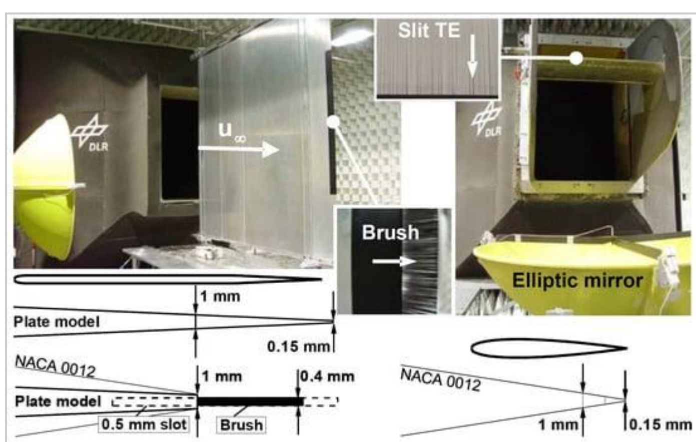

Figure 14: Trailing edge brush experimental set up. Also called slit devices.

VOCAB: (w/definition)	- Leading edge serrations-tooth like on the leading edge of an airfoil can improve efficiency and decrease the amount of noise produced by an airfoil. - Trailing edge serrations-tooth like pattern on the trailing edge that improves the efficiency of an airfoil and also helps decrease the amount of noise produced. - Fringe-type trailing edge extensions-brush like/slit like extensions on the trailing edge inspired by the fringes on owl feathers. - Sawtooth serrations-jagged teeth like serrations that resemble triangles. - Sinusoidal serrations-curved teeth like serrations, and are wavy like. - Reynolds number-ratio of inertial forces to viscous forces. https://www.sciencedirect.com/topics/engineering/reynolds-number
Cited references to follow up on	Sarradj, E.; Fritzsche, C.; Geyer, T. Silent Owl Flight: Bird Flyover Noise Measurements. In Proceedings of the 16th AIAA/CEAS Aeroacoustics Conference, Stockholm, Sweden, 7–9 June 2010. AIAA Paper 2010-3991. Lau, A.S.H.; Kim, J.W. The Effect of Wavy Leading Edges on Airfoil-Gust Interaction Noise. In Proceedings of the 19th AIAA/CEAS Aeroacoustics Conference, Berlin, Germany, 27–29 May 2013. AIAA Paper 2013-2120. Watts, P.; Fish, F.E. The Influence of Passive, Leading Edge Tubercles on Wing Performance. In Proceedings of the Unmanned Untethered Submersible Technology (UUST01), Durham, UK, 21–24 August 2001. Oerlemans, S.; Schepers, J.G.; Guidati, G.; Wagner, S. Experimental Demonstration of Wind Turbine Noise Reduction through Optimized Airfoil Shape and Trailing-Edge Serrations. In Proceedings of the European Wind Energy Conference, Copenhagen, Denmark, 2–6 July 2001. Gruber, M.; Joseph, P.F.; Chong, T.P. On the Mechanisms of Serrated Airfoil Trailing Edge Noise Reduction. In Proceedings of the 17th AIAA/CEAS Aeroacoustics Conference (32nd AIAA Aeroacoustics Conference), Portland, OG, USA, 5–8 June 2011. AIAA Paper 2011-2781.
Follow up Questions	1. As lower Reynolds numbers were observed in general, will these methods and techniques still be applicable to applications that have higher Reynolds numbers? 2. Because noise measurements for the vast majority of experiments are conducted in wind tunnels, how might the results vary under different atmospheric conditions? 3. While individual characteristics were separately looked at, how might the combination of the three characteristics of an owl have changed the results of noise reduction on airfoils? 4. How do these characteristics possessed by an owl vary among animals with wings or fins, and could certain aspects of different

	animals be implemented to optimize power and noise reduction?

Article #10 Notes: Wind turbine bionic blade design and performance analysis

Source Title	Wind turbine bionic blade design and performance analysis
Source citation (APA Format)	Hua, X., Zhang, C., Wei, J., Hu, X., & Wei, H. (2019). Wind turbine bionic blade design and performance analysis. *Journal of Visual Communication and Image Representation*, *60*, 258–265. https://doi.org/10.1016/j.jvcir.2019.01.037
Original URL	https://doi.org/10.1016/j.jvcir.2019.01.037
Source type	Journal Article
Keywords	Numerical simulation, Source of renewable energy, Wind turbine blade
#Tags	Bionic blade
Summary of key points + notes (include methodology)	Wind turbines are a growing source of renewable energy as the need for energy continuously increases. Both blade-element theory and seagull wings are used as models to create three types of bionic wind turbine blades because of their optimal aerodynamic performance. The bionic blades' performances are compared with the performances of standard wind turbine blades, and are assessed through numerical simulation. At varying winds speeds, the completely improved bionic blade torque was 10.2% higher, 14% higher for the partially improved blade, and 7% higher for the configuration improved blade. The experimental results ended up being similar to the simulated results. *Notes not paraphrased-general blurbs Introduction: -Wind turbines are being used more and more, the question is how they can be more efficient. -Theory of momentum blade element, the blade is superimposed of airfoils varying in thickness along the span wise, -Lots of room for wind turbine improvement, current turbines are less than 30% typically. -Using the bionic non-smooth theory, bionic coupling theory and basic

	theory of aerodynamics, seagull wings are used to model airfoils for a wind turbine. 2. Basic theory of wind turbine blades -Lift is made by blade elements of the radius and length along the wing span. -Drag is made by axial momentum rate and rate of angular momentum. -Smaller angle of attack and thin tailing edge=less blade element drag and more lift. 3.1 bionic blade of total improved airfoil -Seagulls have high lift-to-drag ratio, -Basic geometric parameters, and rated power are determined. -Lift coefficient of seagull wings reaches up to 1.92 at an angle of attack of 12 degrees. 3.2 the bionic of partially improved airfoil -For wind turbine blades, the tip largely changes the aerodynamic performances of the blades, and it's the main cause of blade noise. 3.3 Configuration improved bionic blade -Method of making the improved blade is spreading the wind turbine bladed according to the leading edge of seagulls wings. -Aerodynamic centers of all parts of the blade airfoil are in the front line of the seagull wings. 4.1 Numerical simulation conditions -Cylindrical structure calculation domain was picked to make flow field simulation more realistic. -Blade is simulated under rated wind speed. -Standard blade has wind speed of 10m/s. and torque is 14.42 N*m. -Simulation result is higher than rated power. 4.2.1 torque analysis -Torque and power are both important factors for rotating machinery, the

	show the spinning force experienced by an object. -At average speed, torques of bionic blades improve compared to standard blade torque. 4.2.2 Pressure contours analysis -standard blade power isn't high because of small pressure differences on both sides-uneven pressure. -Therefore, surface pressure distribution is affected. -Bionic blade pressure is higher-better efficiency, -Large pressure difference areas during rotation, which may mean the configuration of the blade could reduce drag affecting efficiency when the blades rotate. -5.1 The test method _Test system made of standard wind turbines, 28v three-phase ac permanent magnet generator, rectifier stack, electronic load, anemometer, oscilloscope. -Test system measures power generated, rotational speed of the blade and wind speed. -They convert wind speed to a pulse frequency signal enabling them to measure the real-time wind speed under different rotational speeds. -To measure efficiency, curves of rotational speed and output efficiency are tested from wind speeds 0-12 m/s. -Bionic blade reaches 270 r/min which is 8% higher than regular wind turbine blades and a wind speed of 10 m/s -At low wind speeds, the efficiency of the bionic blade is higher than the standard blade, but the partially improved blade has the highest efficiency, next is the totally improved blade, and third is configuration of the improved blade. -The partially improved airfoil's blade is generally 12% better than the standard blade's, .-Total improved airfoil blades work better at higher wind speeds

<table>
<tr>
<td>Research Question/Problem/ Need</td>
<td>Are bionic wind turbine blades with designs based on the characteristics of seagull wings more efficient than standard wind turbine blades in terms of power output?</td>
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<td>Important Figures</td>
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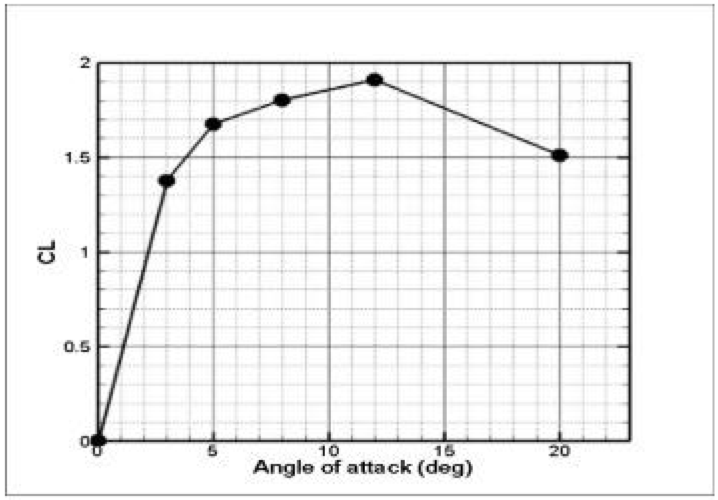
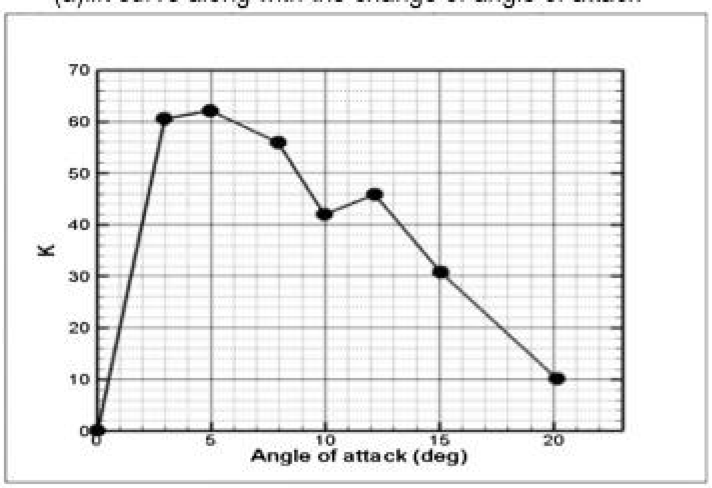


(a)lift curve along with the change of angle of attack



(b) The lift-to-drag ratio curve

Figure 1: (a) represents the lift curve, and the angle of attack is also factored in. (b) represents the lift to drag ratio.

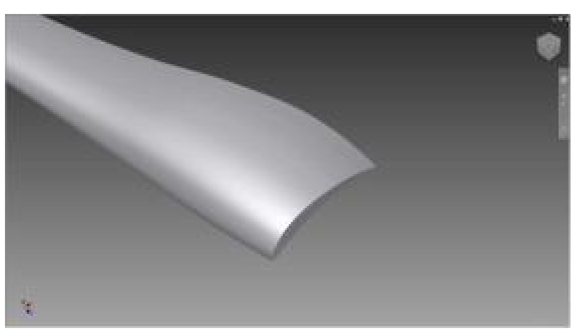


Figure 2: An image of the total improved bionic airfoil.

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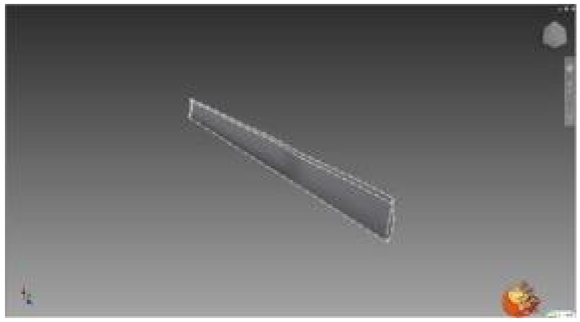


Figure 3: An image of the partially improved bionic airfoil.

Figure 4: Image of the configuration improved bionic blade.

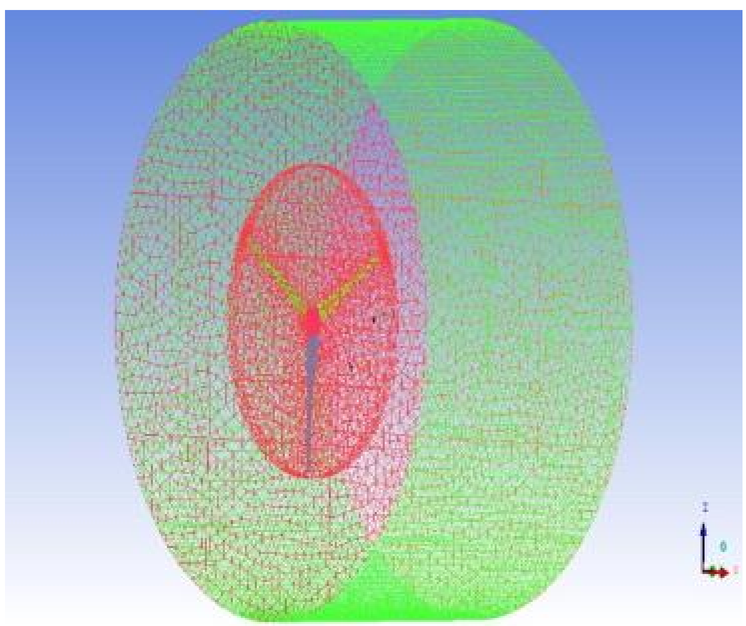
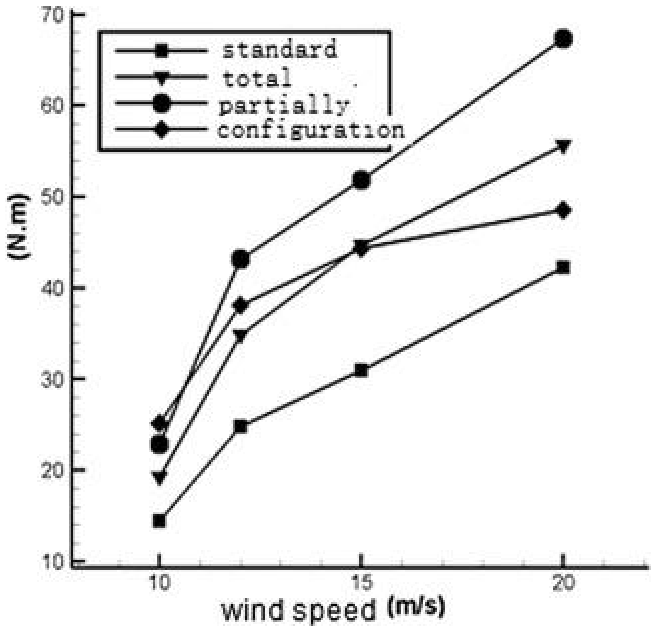


Figure 5:Shows the computational grid.

	 Figure 6: Demonstrates the contrast in torque among the four blades at different wind speeds.

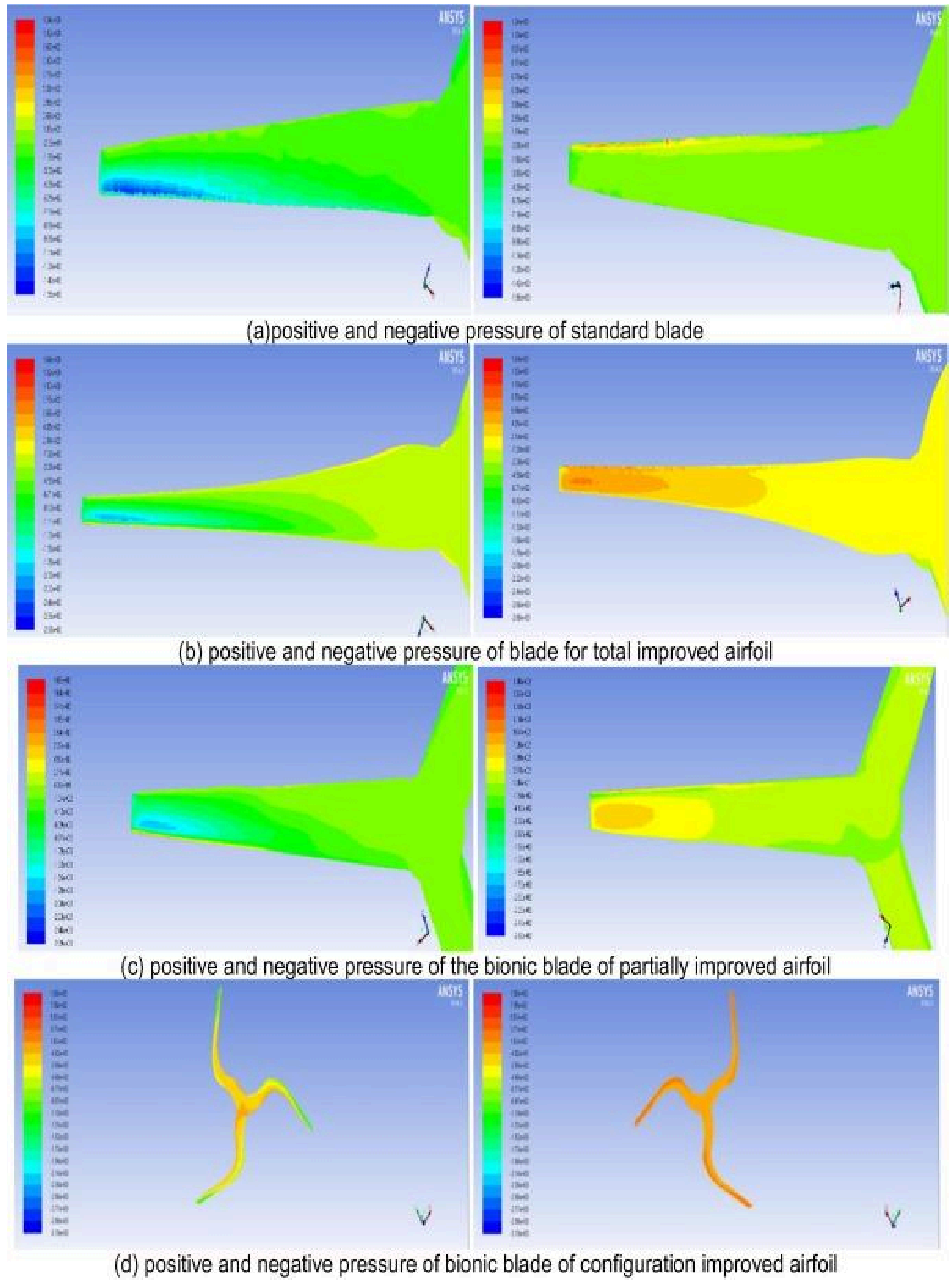
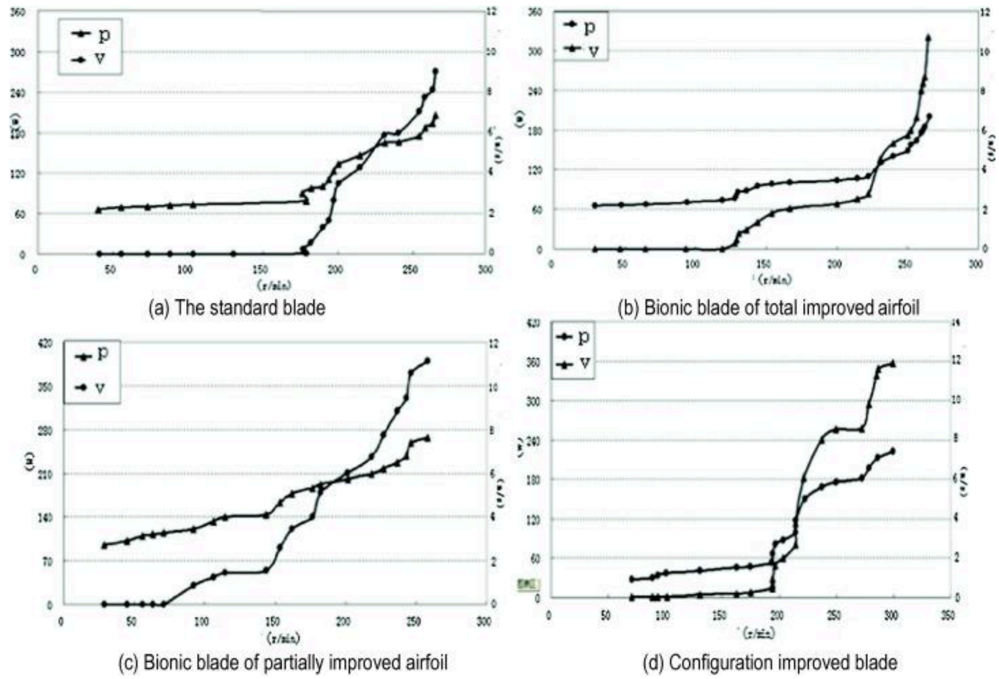


Figure 7: Shows the standard blade and bionic blade pressure contours.

	 Figure 8: Shows the four different blades wind energy utilization coefficients at different wind speeds.
VOCAB: (w/definition)	1. Aerodynamic performance-how well/efficiently an object functions with its interaction with a fluid. 2. Momentum blade element-the blade is superimposed of airfoils varying thickness along the spanwise. 3. Geometric parameters-parameters required to compute direct or indirect geometric models https://www.sciencedirect.com/topics/computer-science/geometric-parameter#:~:text=The%20geometric%20parameters%20concerned%20with,direct%20and%20inverse%20geometric%20models.. 4. Lift coefficient-a number engineers use to model the complex dependencies of shape, inclination, and some flow dependencies on lift. https://www.grc.nasa.gov/www/k-12/rocket/liftco.html 5. Suction surface-also called the upper surface, it has a lower static pressure and a higher velocity. https://monroeaerospace.com/blog/5-facts-about-airfoils-and-how-they-work/ 6. Bionic blade-bio(biology) inspired blade. 7. Boundary Layer Separation-takes place whenever an abrupt change in either the magnitude or direction of the fluid velocity is too great for the fluid to keep to a solid surface. Bioprocess Engineering Principles (Second Edition), 2013
Cited references to follow up on	

	Microstructure and nanomechanical properties of the wing membrane of dragonfly Mater. Sci. Eng., A, 457 (2007), pp. 254-260 M. Sterling, A.D. Quinn, D.M. Hargreaves, *et al.* A comparison of different methods to evaluate the wind induced forces on a high sided lorry J. Wind Eng. Ind. Aerodyn., 98 (1) (2010), pp. 10-20 L. Zhang, R. Hong, Y. Gao, R. Ji, Q. Dai, X. Li Image categorization by learning a propagated graphlet path IEEE T-NNLS, 27 (3) (2016), pp. 674-685 Till Deubel Modeling and manufacturing of a dragonfly wing as basis for bionic research International Design Conference Dubrovnik-Croatia (2006), pp. 15-18 P.L. Tubaro A comparative study of aerodynamic function and flexural stiffness of outer tail feathers in birds J. Avian Biol., 34 (2003), pp. 243-250
Follow up Questions	1. Did the change in efficiency throughout the bionic airfoils also have a large effect on the amount of noise produced? 2. Could these different bionic blades' efficiency be affected by different pressures, humidity, and other atmospheric conditions? 3. How come different wind speeds affect which airfoil is the most efficient? 4. Could aspects of all three be combined/averaged to create an overall more efficient wind turbine? 5. What specific aspects of seagull wings were applied allowing the bionic blades to be more efficient?

Article #11 Notes: Wind Turbine Blade Design

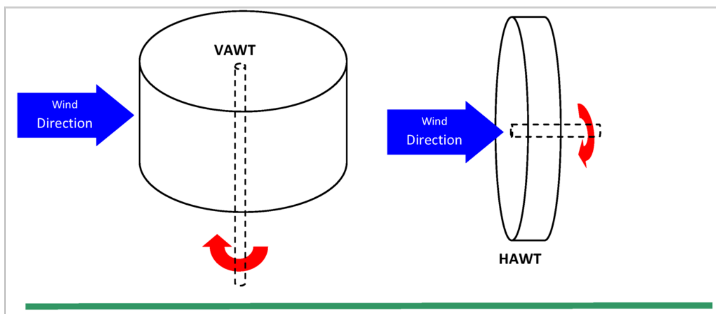
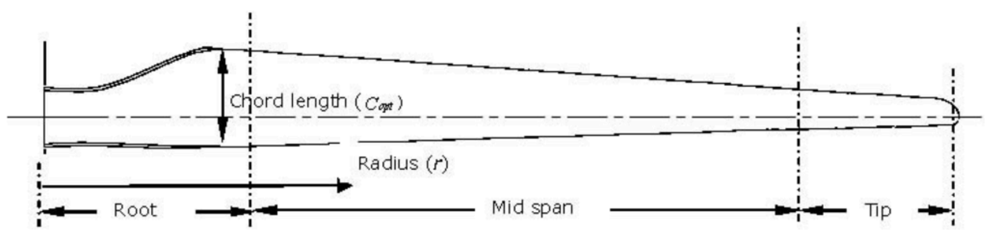
Source Title	Wind Turbine Blade Design

Source citation (APA Format)	Schubel, P. J., & Crossley, R. J. (2012). Wind Turbine Blade Design. *Energies*, *5*(9), 3425–3449. https://doi.org/10.3390/en5093425
Original URL	https://www.mdpi.com/1996-1073/5/9/3425
Source type	Journal Article
Keywords	Wind turbine, blade design, aerodynamic, betz limit
#Tags	Wind turbine, blade design
Summary of key points + notes (include methodology)	Horizontally mounted wind turbines with three blades are the most commonly used due to aesthetics, efficiency, fortitude against the elements, and noise control. Many other designs were used through the development of the current design, but eventually fell off in popularity. Wind turbines are being increased in size, however this is accompanied by different issues. This article looked at blade design, and determined optimal shapes for blade efficiency depends on different parameters. These include secretions varying in thickness, a twist angle towards the hub, and the lift and drag produced. A simple load analysis shows that structural factors will affect the given thickness of certain areas of the blade. Wind turbines will likely continue to grow in size with small changes to improve efficiency until a cap on size is reached. *Notes not paraphrased Wind Turbine Blade Design Notes 1. Introduction -Wind mills have been used for centuries as a way of harnessing wind energy. -Wind turbines are first classified by their shaft and rotational axis, a horizontal shaft parallel to the ground (HAWT) and a vertical axis (VAWT) -The VAWT is not used as much as the HAWT, this is largely due to its small tip speed ratio and the troubles accompanying controlling the rotor speed. -HAWT has better rotor control, pitch and yaw control, making it more commonly used at the time this article was written (2012). 2. Theoretical Maximum Efficiency

	-High rotor efficiency is important Energy (P) p=air density A=swept area V=air velocity P=1/2pAV^3 -Complete (100%) wind harnessed would mean 0 final velocity meaning 0 flow, this isn't attainable because not all of the kinetic energy from wind can be utilized. -It is indicated that wind turbine efficiency can't surpass 59.3%, assuming constant linear velocity. This is known as the power coefficient Cp, Cp=0.593-Betz limit. -To avoid efficiency reductions: "Avoiding low tip speed ratios which increase wake rotation ● Selecting airfoils which have a high lift to drag ratio ● Specialized tip geometries" 3. Propulsion -Historically, drag was the most used method of propulsion, however this proves to be inefficient. -Efficiency was further hindered by the drag of the returning sail into the wind. -Designs that are unshielded have curved blades that have smaller drag coefficient, and work in any direction. Differential drag rotors used in anemometers and ventilation cowls, tip speed ratio can't pass one. -Aerodynamics has become its own subject because of the growing complexity involved, -Lift can be created in a narrow corridor at different angles in perspective of wind direction, meaning there is no decrease in relative wind speed with any rotor speed, and this is important to wind turbine rotors. 4.Practical Efficiency -Different designs have been made over the years to try and further

	maximize wind turbine efficiency. 5.HAWT Blade Design -Tip speed ratio is the relationship between rotor blade velocity and win velocity, efficiency, torque, mechanical stress, and noise should be noted when choosing. -Higher tip speeds=higher efficiency, however causes mechanical stress and noise generation. -Higher tip speed means lower cord widths getting narrower. -Blades meant for greater wind speeds have trouble starting due to increase in torque. -Noise increases as wind speed increased proportionally to the sixth power. -Modern HAWT typically have a tip speed ratio 9/10 for two lades, and 6/9 for three blades. -more efficient -Betz theory is good for calculating the best cord length when blades have tip speed ratios of 6/9, but with low tip speeds, high drag, it isn’t accurate. -If a steady lift coefficient that is reasonable is present, a blade optimization method can make blade plans that depend mostly on rotors with high ratios of solidarity-ratio of blade area to area of the swept rotor. -Optimal chord dimensions, quantity of blades is not important compared to efficiency. When considered when they actually occur however, 3% loss for two blades, 7-13% loss for one blade compared to three blades. -Three bladed turbines are typically more aesthetic, faster two blades and one blade appear more “rough”. -Fewer blades means lower nacelle weight, three bladed wind turbines are more common due to aesthetic, environmental, commercial, and economic restrictions. -Drag is created by friction-must reduce. -Lift to drag ratio=coefficient of lift/coefficient of drag -Typically tested with varying Reynolds numbers, angles of attack. -Wind turbine blades must be made to withstand soiling because they are so close to the ground unlike plane wings.

	-In the root area, airfoils with high thickness to chord ratio must be used. -National Advisory Committee for Aeronautics have designs with four and five digits, 1st digit=maximum chamber to chord ratio, 2 is chamber position, 3 and 4 are maximum thickness to chord ratio. -difference in airfoil location is important considering aerodynamic performance due to constraints. -Stall conditions-caused by high wind speeds and large angles of attack must be taken into consideration. -Rotational speed must be limited to maintain blade, hub, gearbox, and generator. -Pitching is changing the blade pitch due to high wind speeds, t is done to minimize blade speed. -Smart blade design is being used to optimize future wind turbines, smart materials are materials that are able to sense and actuate in a controlled way as a response to variable ambient stimuli. -Angle of twist chord width, and airfoil profiles must be taken into account. - 6. Blade Loads -The main sources of blade loading are aerodynamic, gravitational, centrifugal, gyroscopic, and operational. -Aerodynamic load is made by lift and drag, -Gravitational load is mass times gravitational constant -Centrifugal loads is rotational velocity times the mass -Structural load analysis is usually found with the Finite Element Method -Flap wise bending is caused by aerodynamic loads which are found using BEM theory, -Edgewise bending is a result of blade mass and gravity. -Fatigue loading happens when a material repeated non continuous load occurs causing the fatigue limit to be surpassed. -Fatigue loading occurs due to gravitational cyclic loads-number of rotations

	the turbine ever experiences. 3 sections of wind turbine blade: -Blade root-circular mound to first profile, has highest loads, low wind velocity, reduced aerodynamic lift, -thick -mid span-important, lift to drag ratio at its max, -thin as possible, tip-lift to drag at max, slender airfoils to reduce noise,
Research Question/Problem/ Need	What different factors affect the blade design of a wind turbine blade, and how do these affect its efficiency?
Important Figures	 Figure 1: Displays different configurations of shaft and wind turbine rotors. One displays a horizontal configuration, while the other displays a vertical configuration, the horizontal configuration is more widely used.  Figure 2: Displays a typical diagram of a wind turbine blade, it labels the chord, radius, root area, mid section, and tip.

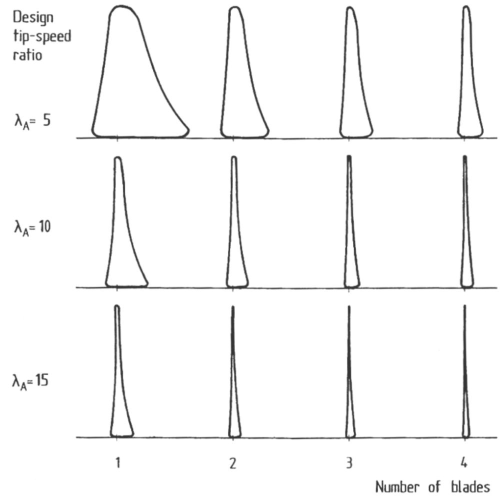


Figure 3: Displays the optimal blade plan shape for different design tip speed ratios.

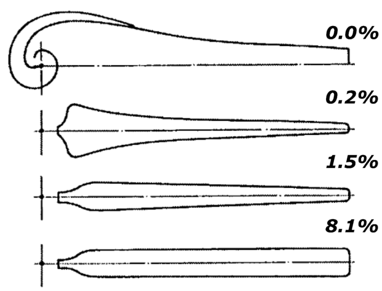


Figure 4: Displays the efficiency lost when the chord length is simplified.

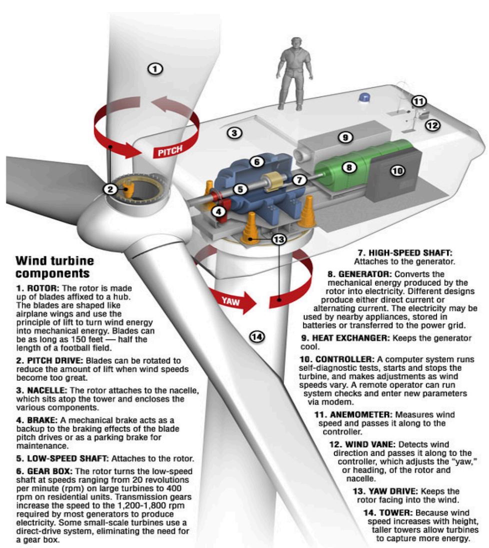


Figure 5: Depicts a diagram of the typical modern day large wind turbine, labeling the different parts and their function.

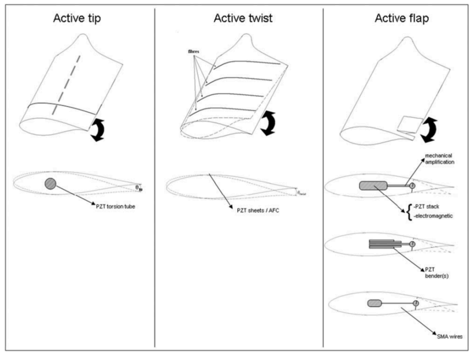


Figure 6: Displays different factors of smart structure concepts.

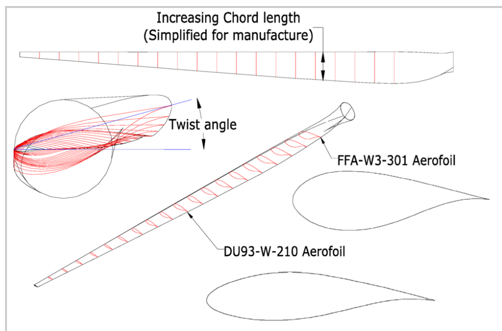


Figure 7: Displays the typical modern HAWT blade (horizontal rotor configuration) with an increase in twist and linear chord length, accompanied by multiple profiles.

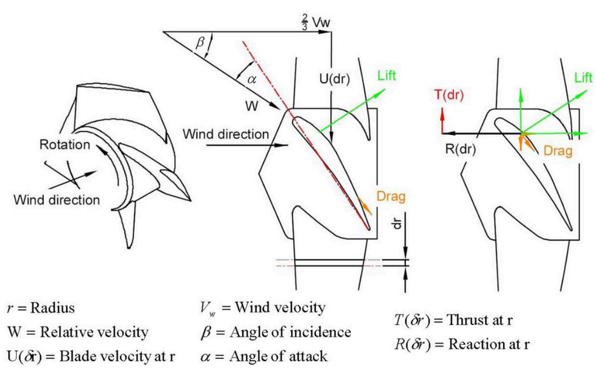


Figure 8: The aerodynamic forces generated at blade element.

VOCAB: (w/definition)

1. Betz limits-theoretically the maximum efficiency of a wind turbine, 59.3%.
2. Chord-the distance to the leading edge from the trailing edge. https://skybrary.aero/articles/chord-line
3. Smart blades-blades that alter their shape as a result of different wind conditions.
4. Airfoil profile-the section of an airfoil when sliced from the leading to trailing edge.

	5. Gyroscopic load-the load/force exerted on the wind turbine as a result of its rotations.
Cited references to follow up on	Hau, E. *Wind Turbines, Fundamentals, Technologies, Application, Economics*, 2nd ed.; Springer: Berlin, Germany, 2006. Dominy, R.; Lunt, P.; Bickerdyke, A.; Dominy, J. Self-starting capability of a darrieus turbine. *Proc. Inst. Mech. Eng. Part A J. Power Energy* 2007, *221*, 111–120. Holdsworth, B. *Green Light for Unique NOVA Offshore Wind Turbine*. 2009. Available online: http://www.reinforcedplastics.com (accessed on 8 May 2012). Gasch, R.; Twele, J. *Wind Power Plants*; Solarpraxis: Berlin, Germany, 2002. Gorban, A.N.; Gorlov, A.M.; Silantyev, V.M. Limits of the turbine efficiency for free fluid flow. *J. Energy Resour. Technol. Trans. ASME* 2001, *123*, 311–317.
Follow up Questions	1. Could wind turbines be made so they aren't overwhelmed during extreme conditions? 2. Could a specific id turbine be designed to extract energy from extreme weather (and extreme wind speeds)? 3. How does each section of the wind turbine blade contribute to the sound generated? 4. The effects of 1, 2, and 3 wind turbine blades is known, would it be beneficial to use more than three blades on a wind turbine? 5. How could minor improvements in aerodynamic performance compare against creating bigger wind turbines in terms of efficiency?

Article #12 Notes:Cumulative Impact of Wind Farm Noise

Source Title	Cumulative Impact of Wind Farm Noise
Source citation (APA Format)	Josimović, B., Bezbradica, L., Manić, B., Srnić, D., & Srebrić, N. (2023). Cumulative Impact of Wind Farm Noise. *Applied Sciences*, *13*(15), 8792. https://doi.org/10.3390/app13158792

Original URL	doi.org/10.3390/app13158792
Source type	Journal Article
Keywords	Noise, cumulative impact, wind farm, strategic environmental assessment
#Tags	Cumulative impact
Summary of key points + notes (include methodology)	Wind turbines are overall beneficial for the environment, but are also accompanied by negative aspects as well. They generate noise, and as the distance to the turbine increases, so does the noise produced. However, when there is more than one wind farm in a given area, a superposition of noise occurs, affecting noise levels. This paper focused on modeling noise in a given area with two wind turbine farms in the vicinity. The results are then modeled to determine the different territorial effects allowing decisions to be made about the development of another wind farm. ● ● There are different levels of impact from noise on human health, discomfort, distraction, discontent, obstruction of conversation, sleep, studying, physiological effects such as anxiety, tinnitus, or hearing loss. ● Most common effects of people near wind turbines are anxiety, sleepiness, fatigue, irritability, reduced sleep quality prominently with noise levels greater than 45 dB. ● Low frequency sound is more concerning. ● The ISO 9613 is an optimal model for noise levels. ● It was improved to include topographic conditions, and was used on three European wind power plants. ● Noise levels from two wind farms part of the Portland Wind ENergy Project were also looked at. Measured according to New Zealand Standard No. 6808, compared to sum of predicted noise, and average noise levels before there was a wind farm. ● Planned in northern Serbia, a low lying plain area, a wind farm was previously developed and is currently operating, while the Vetrozelena Wind Farm is being prepared. ● Method from SEA used. ● Local legislation set criteria for acceptable noise levels. ● Space is low-lying land, and there are several rural settlements in the vicinity. ● Paper mainly focuses on the noise aspect which was integrated into the SEA procedure. ● 57 GE Wind Energy Ge 2.75-120 turbines that operate in Cibuk and the future Vetrozelena were modeled. ● Input positions, type of wind turbines, wind speed were key input

	data. ● Parameter was set for 8 m/s wind speed 10 m above ground, ● Increased distance from turbines, atmospheric absorption, and sound absorption from noise passing through soil to a receptor were identified. ● Separate models for each of 49 and 57 wind turbines were made. ● Calculating the cumulative effect takes into account size and number of turbines, distance between farms, and topographical data. ● Porous ground had negligible effects on sound. ● Effects of noise are modeled on noise receptors, in the zone of impact. ● 8 receptors are identified ● The increase in noise cumulatively is identified. ● DEtrimental positions can be identified with this modeling system, and can be applied to the SEA process.
Research Question/Problem/ Need	How are sound levels changed when there is more than one wind farm in a given area?

Important Figures	 Figure 1:Location of the the study (where the wind turbines are in Serbia)

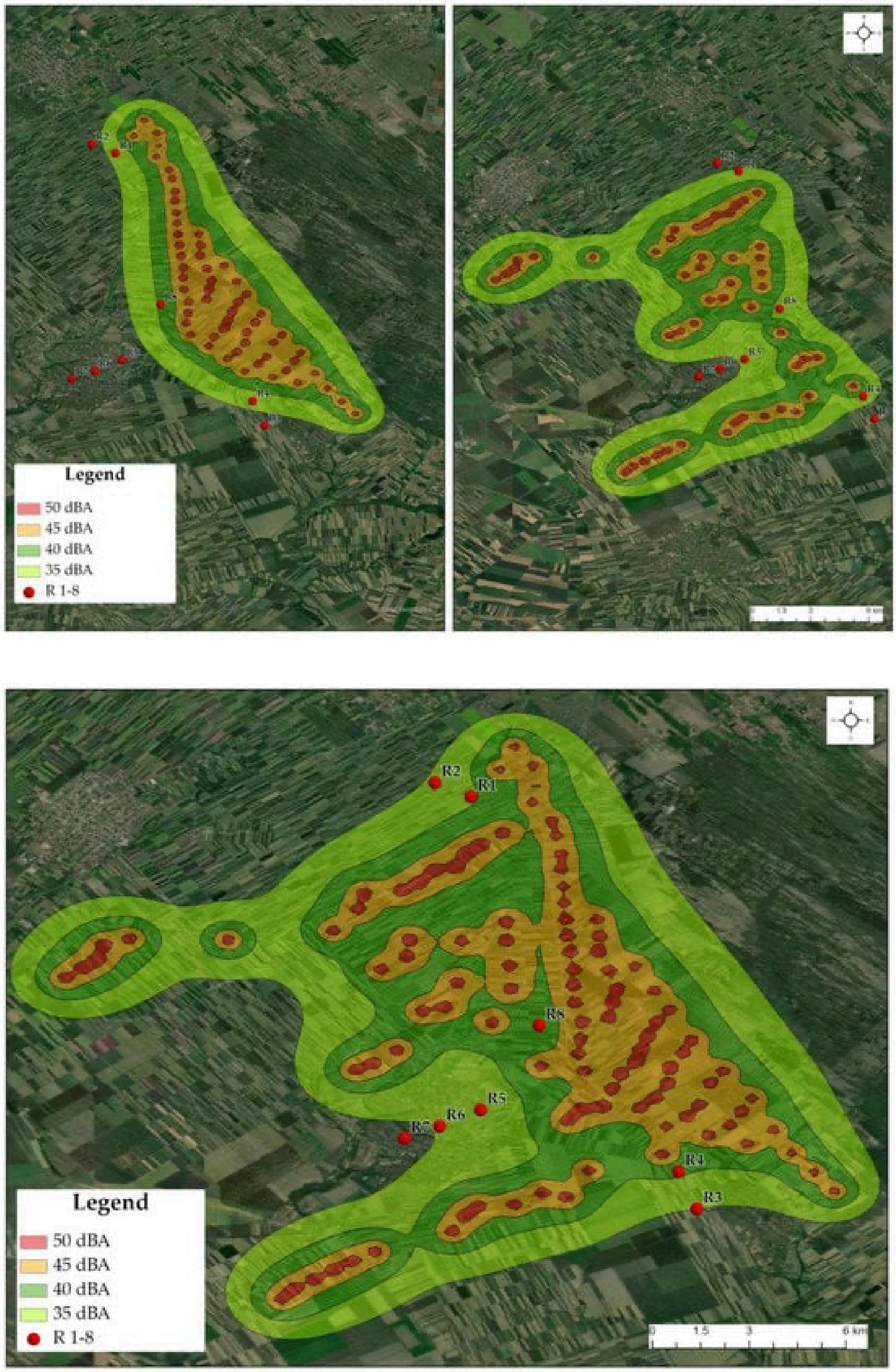
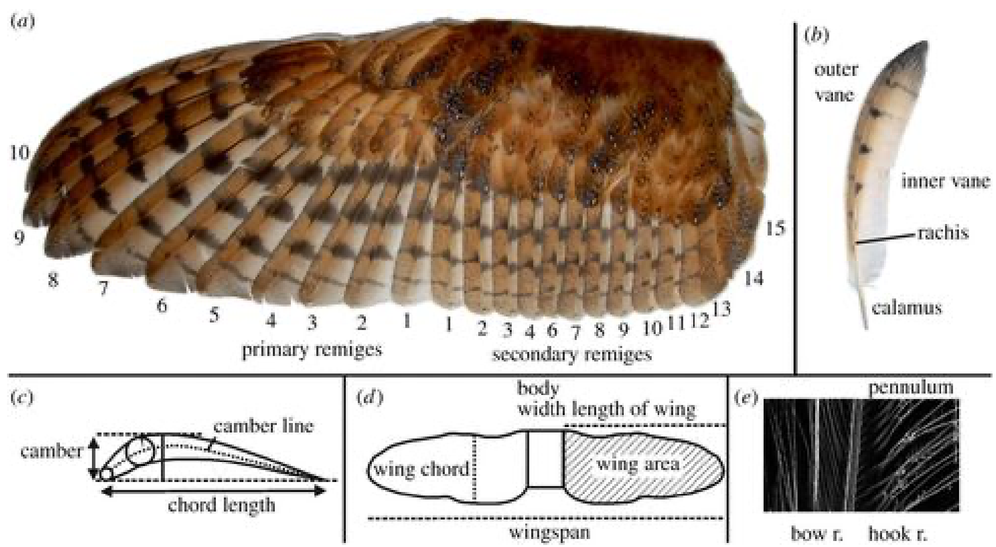


Figure 2: First two images depict noise value outlines for individual farms , while the third depicts the cumulative effect of when the farms are in the same vicinity.

VOCAB: (w/definition)	1. Porous ground- ground with minute spaces which liquid or air can pass through. - Oxford Languages 2. Superposition - action of placing one thing above another, especially so they coincide. - Oxford Languages 3. Infrasound-sound waves with frequencies below the lower limit of human audibility. -Oxford Languages 4. Holistic approach- the belief that the parts of something are interconnected and can be explained only by reference to the whole. -Oxford Languages
Cited references to follow up on	Pedersen, E.; Waye, K.P. Wind turbine noise, annoyance and self-reported health and well-being in different living environments. *Occup. Environ. Med.* **2007**, *64*, 480–486. [**Google Scholar**] [**CrossRef**] [**PubMed**][**Green Version**] Schomer, D.P.; Erdreich, J.; Pamidighantam, K.P.; Boyle, J.H. A theory to explain some physiological effects of the infrasonic emissions at some wind farm sites. *J. Acoust. Soc. Am.* **2015**, *137*, 1356–1365. [**Google Scholar**] [**CrossRef**] Maizi, M.; Mohamed, M.H.; Dizene, R.; Mihoubi, M.C. Noise reduction of a horizontal wind turbine using different blade shapes. *Renew. Energy* **2018**, *117*, 242–256. [**Google Scholar**] [**CrossRef**] Karasmanaki, E. Is It Safe to Live near Wind Turbines? Reviewing the Impacts of Wind Turbine Noise. *Energy Sustain. Dev.* **2022**, *69*, 87–102. [**Google Scholar**] [**CrossRef**] Nissenbaum, A.M.; Aramini, J.J.; Hanning, D.C. Effects of industrial wind turbine noise on sleep and health. *Noise Health* **2012**, *14*, 237. [**Google Scholar**] [**CrossRef**] [**PubMed**] Colten, H.R.; Altevogt, B.M. *Sleep Disorders and Sleep Deprivation: An Unmet Public Health Problem*; National Academies Press: Washington, DC, USA, 2006. [**Google Scholar**] [**CrossRef**] Jalali, L.; Bigelow, P.; Nezhad-Ahmadi, M.R.; Gohari, M.; Williams, D.; McColl, S. Before–after field study of effects of wind turbine noise on polysomnographic sleep parameters. *Noise Health* **2016**, *18*, 194. [**Google Scholar**] [**CrossRef**] [**PubMed**]
Follow up Questions	1. Can the turbine positions be set so that the sounds created by one are canceled out by the sound created by the other? 2. How would this differ if the wind wasn't coming directly at the turbines? 3. What is the sound superposition like with unusually high wind speeds? 4. How would these results be changes in different topographical circumstances?

Article #13 Notes: Features of owl wings that promote silent flight

Source Title	Features of owl wings that promote silent flight
Source citation (APA Format)	Wagner, H., Weger, M., Klaas, M., & Schröder, W. (2017). Features of owl wings that promote silent flight. *Interface Focus*, *7*(1), 20160078. https://doi.org/10.1098/rsfs.2016.0078
Original URL	https://royalsocietypublishing.org/doi/10.1098/rsfs.2016.0078
Source type	Journal Article
Keywords	Fringes, Owls, morphological adaptations, serrations
#Tags	Morphological adaptations
Summary of key points + notes (include methodology)	Owls are known for their ability to hunt silently. This article looks at different experiments regarding the morphological adaptations of works that promote silent flight. They also discuss the different aerodynamic features involved with owls wings. Owls large wings, and therefore small loading and aspect ratio aid owls' silent flight. Their trailing edge fringes that are integrated with the grooves at the lower wing section have shown to lower the noise produced by trailing edges. The different noise reduction agents utilized by owls still have to be effectively integrated into fixed airfoils. ● *Notes are general blurb, may not be entirely paraphrased. ● Birds have always been a major inspiration for humans. ● Birds do differ in some ways, ie. flexible wings, aerodynamic characteristics, Reynolds numbers (closer to model planes), ● Main focus is reduction in flight noise. ● Noise = loss of energy, and noise from planes have been linked to health issues like increased blood pressure. ● Owls may have adapted to fly quietly due to a low hearing threshold. ● Mains features of a wing: chord length, wing span, wing area, thickness, camber. (Camber = quotient of deviation from the wing's center line, the camber, (connecting trailing edge and leading edge). ● Aspect ratio and wing loading can be derived from this. ● Feathers- shaft and vane. ● Velvety feathers (like a cushion, so feathers against each other are quiet) and trailing edges ● In one experiment, serrations got rid of the leading edge bubble by

	making turbulence. ● Sound produced by the owl wasn’t changed by serrations when it was flapping. ● Lilley in an experiment identified that leading edge serrations worked similarly to co-rotating vortex generators -reduce noise. ● One study comparing owls with other birds concluded owls were on average quieter than other birds, such as a buzzard and non-silent flyers. ● Camber on bird wings isn't fixed, and often changes while the wing is flapping, these wings can adapt the camber around the flow field, which may explain why they don’t stall with wings with high camber. ● Serrations can be described by length, thickness, width, angles ● Lift is affected not as much by serrations, but by trailing edge vortices. ● .Exact details about serrations geometry is still not yet known. ● Velvety feathers aided in boundary layer control ● Fringes have also been looked into regarding the silence of owls, and these essentially lower the number of trailing edges which are a large source of noise.
Research Question/Problem/ Need	What owl adaptations lower the noise produced by owl wings, and how can these be applied to different innovations.
Important Figures	 Figure 1: The characteristics of a barn owl are first displayed. It shows the different feathers, including primary and secondary feathers. This allows the characteristics discussed in the article. The next image depicts one of the primary feathers of an owl. The last two figures depict chord and camber lines, aiding in the explanation later of flexible chamber lines.

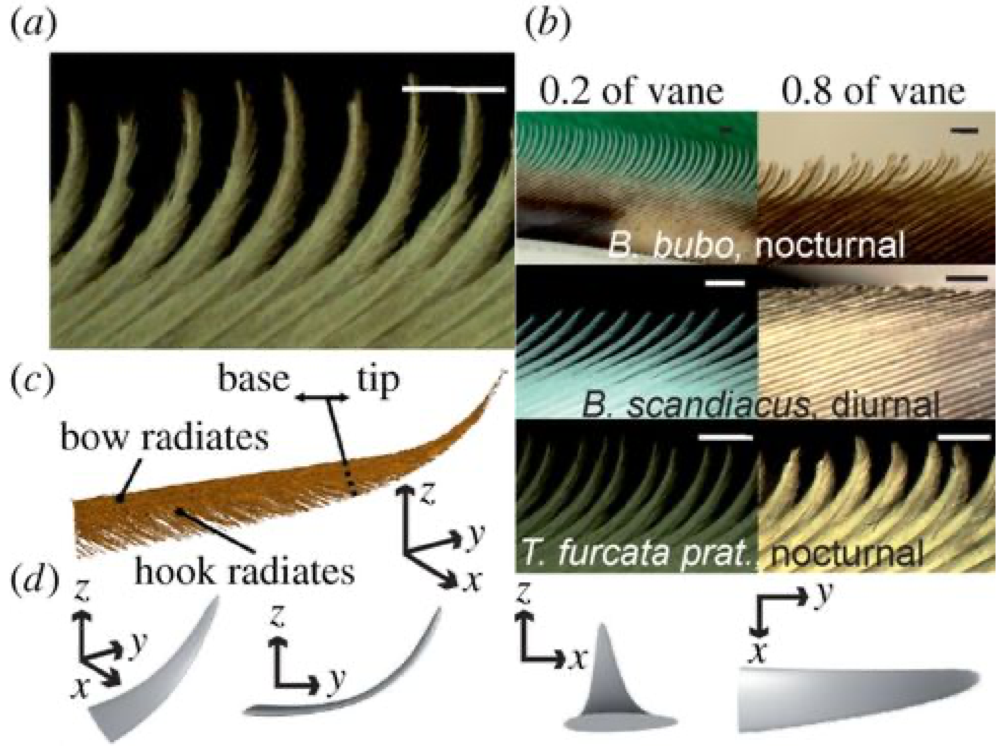
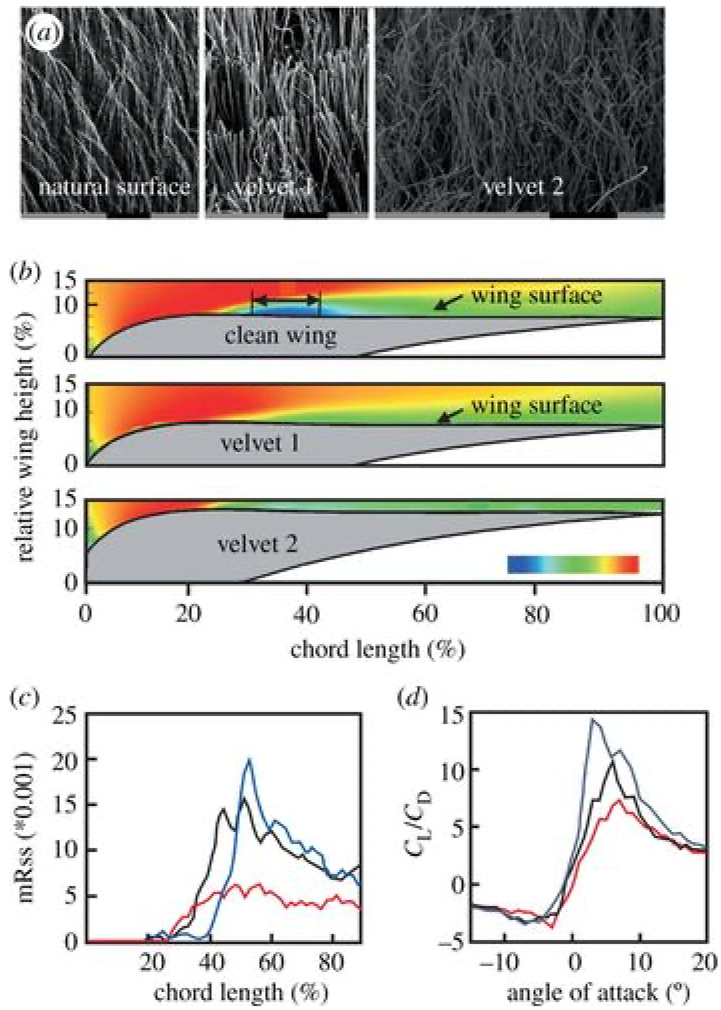


Figure 2: Displays a variety of serrations on an eagle-owl., snowy owl, and barn owl. Bow and hook serrations are displayed, as well as first order serrations. (d) particularly places the hooked serration in a 3D plane to offer different angles and perspectives to go along with the description provided.

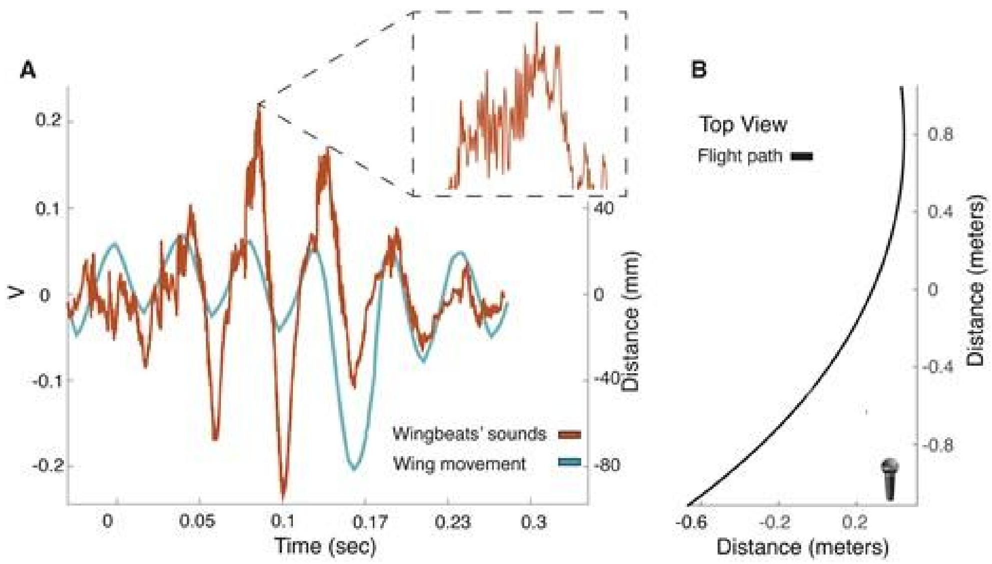
	 Figure 3: Displays the aerodynamic effects of the different velvety like surfaces.) The natural surface, and the artificial structures velvet 1 and velvet 2. The surface of velvet 1 was chosen to mimic the natural surface as much as possible with respect to the softness, length of hairs and density of hairs. Velvet 2 possessed longer hairs. (*b*) Flow field measured at 0.3 spanwise position, an angle of attack of 6° and a Reynolds number of 60 000 in the different configurations. The inset shows the velocity scale ($u/u\infty$) ranging from −0.2 (blue) to 1.2 (red). The arrows point to the upper wing surface. (*c*) Maximum Reynolds shear stress (mRss) as a function of chord length for the different wing configurations. (*d*) The lift-to-drag ratio as a function of the angle of attack for the different wing configurations. *C*Land *C*D are the lift and drag coefficients, respectively
VOCAB: (w/definition)	-Morphology- biological characteristics/geometry of owl wings (in this given context). -Serrated barb- base of the feather where the bow and hook radiates are long and connected to from a closed vane.

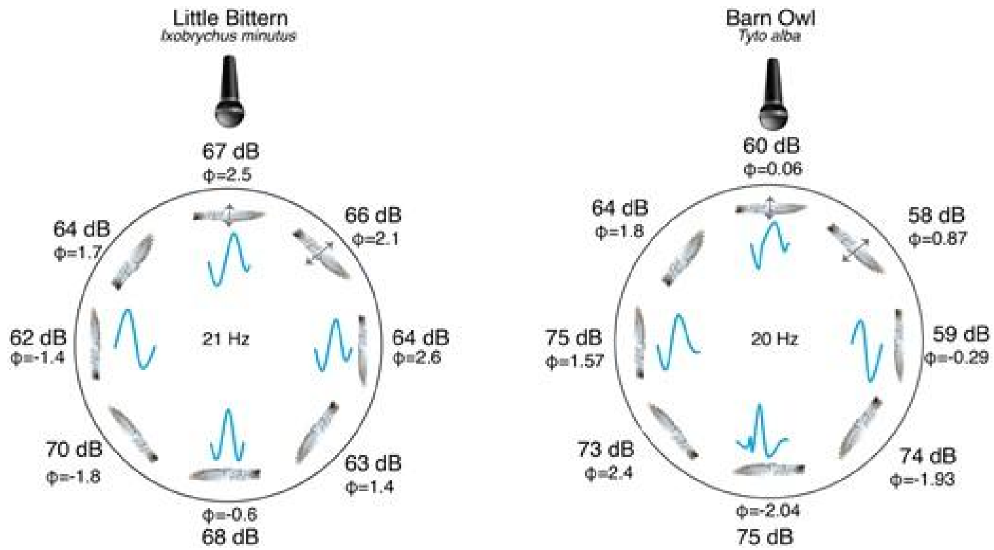
	-Peninsula-filamentous distal part of the radiates on an owl feather. -Strouhal number- the ratio of inertial forces due to the local acceleration of the flow to the interior forces due to the convective acceleration. https://www.sciencedirect.com/topics/engineering/strouhal-number
Cited references to follow up on	1 KleinHeerenbrink M, Hedenström A. 2017 Wake analysis of drag components in gliding flight of a jackdaw (*Corvus monedula*) during moult. *Interface Focus* 7, 20160081. (doi:10.1098/rsfs.2016.0081) 2 Ros IG, Bhagavatula PS, Lin H-T, Biewener AA. 2017 Rules to fly by: pigeons navigating horizontal obstacles limit steering by selecting gaps most aligned to their flight direction. *Interface Focus* 7, 20160093. (doi:10.1098/rsfs.2016.0093) 3 Siddall R, Ortega Ancel A, Kovač M . 2017 Wind and water tunnel testing of a morphing aquatic micro air vehicle. *Interface Focus* 7, 20160085. (doi:10.1098/rsfs.2016.0085) 4 Ortega Ancel A, Eastwood R, Vogt D, Ithier C, Smith M, Wood R, Kovač M. 2017 Aerodynamic evaluation of wing shape and wing orientation in four butterfly species using numerical simulations and a low-speed wind tunnel, and its implications for the design of flying micro-robots. *Interface Focus* 7, 20160087. (doi:10.1098/rsfs.2016.0087) Tank J, Smith L, Spedding GR. 2017 On the possibility (or lack thereof) of agreement between experiment and computation of flows over wings at moderate Reynolds number. *Interface Focus* 7, 20160076. (doi:10.1098/rsfs.2016.0076) König C, Weick F. 2008 *Owls of the world?* 2nd edn. New Haven, CT: Yale University Press. Payne RS. 1971 Acoustic location of prey by barn owls (*Tyto alba*). *J. Exp. Biol*. 54, 535–573. Konishi M. 1973 How the owl tracks its prey. *Am. Sci*. 61, 414–424.
Follow up Questions	1. Which evolutionary forces drove the development of certain adaptations? 2. How can the velvety feathers adaptation be applied to airfoils? 3. Is there a certain combination of trailing edge fringes, leading edge serrations, and velvety feathers that works optimally? 4. What other aspects that are unique to wings vs. fixed airfoils are there?

Article #14 Notes: Wing-Beat Frequency and Its Acoustics in Birds and Bats

Source Title	Wing-Beat Frequency and Its Acoustics in Birds and BAts
Source citation (APA Format)	Boonman, A., Yovel, Y., & Eitan, O. (2020). Wing-Beat Frequency and Its Acoustics in Birds and Bats. *Integrative and Comparative Biology*, *60*(5), 1080–1090. https://doi.org/10.1093/icb/icaa085
Original URL	https://doi.org/10.1093/icb/icaa085
Source type	Journal Article
Keywords	Animal flight, wind-noise, wind turbines
#Tags	Animal flight
Summary of key points + notes (include methodology)	The acoustics of wind turbines and planes can be improved through the study of animal flight. This article looks at the effects of winged birds and bats on sound. Moreover, this study found more acoustic measurements of individual moving wings as well as different moving surfaces, precisely tracking their motion paths. A relationship between the wing-surface area and sound pressure level of wing beat was found, and typically bats were quieter than birds. Isolating the wings and measuring acoustics, it was found that a downstroke in the direction of the microphone resulted in negative sound pressure then turned into positive pressure on the upstroke. When the microphone was above the downward wingbeat, there was a fast rise in sound pressure when the wing was moving down. The impulse from the phase pattern varied as a result of different recording angles. The wing curvature affected the average frequency of the acoustic impulse. This study has the capability to be utilized on small flying animals where the repetition of the wing beats has a greater effect on the acoustics. Notes general blurbs, not paraphrased. Introduction: -Previous studies focuses on sound created by wind going over feathers -Little is known about wing-beat conjunction for bats and birds, while it has

	been looked at in insects. -Insect wings create sound because of vortex edge scattering because of drag and lift. -Dipole-source is a source that has a simultaneous pressure peak adjacent to a trough, causing the sound field to shift 18- degrees in their hemisphere. -Loudspeakers and microphones have sound fields, so do wings. -Four birds and 3 bat species were looked at, and they tried to analyze the noise recorded by looking at the sound of flapping cut off wings. Methods: -Additional experiments included moving the cut-off wings and surfaces relative to the microphone. -Used flight room (5.5*4.5*2.5m), release a single bird or bat from one side of the room, and they take the flights that were close enough to the microphone to produce data. -Microphone was 0.85 m up and 30 degrees angled up. -Sounds were synchronized with 3D tracking system , -Used House sparrow (Passer domesticus), Whitespectacled bulbul (Pycnonotus xanthopygos), Common Myna (Acridotheres tristis), and a City/ rock dove (Columbia livia) and of the following bats: Mouse-tailed bat (Rhinopoma microphyllum), Big brown bat (Eptesicus fuscus) and Rousettus bat (Rousettus aegyptiacus). -Rousettus bat was the only animal not to resemble a common recording situation. -Little Bittern (Ixobrychus minutus, L ¼ 0.16 m), Barn owl (Tyto alba, L ¼ 0.30 m), a ping-pong racket (0.24 m diameter 0.009 m thickness), and a plank (0.98 0.05 0.008 m) were the wing shaped object -Motion was tracked at 200 frames a second, markers were attached to the bats and birds -A directional microphone was used and there was no windscreen, -The sound recordings were processed and added to 3D tracking data using MATLAB, -Unsampled data to 88.2 kHz -Bird/bat to microphone distance was calculated at every point in the flight, -The furthest points were chosen to calculate SPL -USing equation, measurement was standardized to 1 meter -Inferred orientation of bird/bat in relation to the microphone -Created a CAD curved wing to test how it affects frequency of acoustics, -Plotted sound with each flightpath –On birds only there is small noisy patches on low-frequency sinusoid-feather noise -Morse wavelet transform was calculated to look at frequency of acoustic signal -To confirm the feathers made sinusoidal noise, they wrapped a Little Bittern wing in plastic. -To differentiate the frequency made by air pressure differences made by a wing flap and the repetition creased by wingbeat rate, the first was isolated using cut off wings

	-When a surface is moved quickly towards the microphone and quickly stopped, the result is negative pressure, and turns to positive and "dissolves" -To test whether curvature in the wing would change the single flap frequency, 4 identica; plastics wings that only changed in curvature were tested.
Research Question/Problem/ Need	How does wing-beat frequency affect the acoustic produced by bats and birds?
Important Figures	**Fig. 2**  **From recordings and flight-path as depicted in Fig. 1, we extracted the sound pressure (red line) and the vertical movement of the left-wing relative to the body (blue line), both as a function of time (s). The right-hand panel shows the flight path of the bird (*P. domesticus*) as seen from above. In the left panel, the vertical axis denotes the voltage recording by the microphone, with the maximum corresponding to 68 dB SPL (re 1 m). An inset shows an enlargement of the first peak containing a higher frequency noise that we demonstrate to feather noise (see section "Verification of the feather noise") on top of pressure waves originating from the wingbeat strokes of the bird. Note that the amplitude of the noise is ~1/16th to 1/18th of the total pressure. The red and blue lines suggest that negative pressure occurs at the downstroke, a phenomenon confirmed in subsequent tests. Online version in color.**



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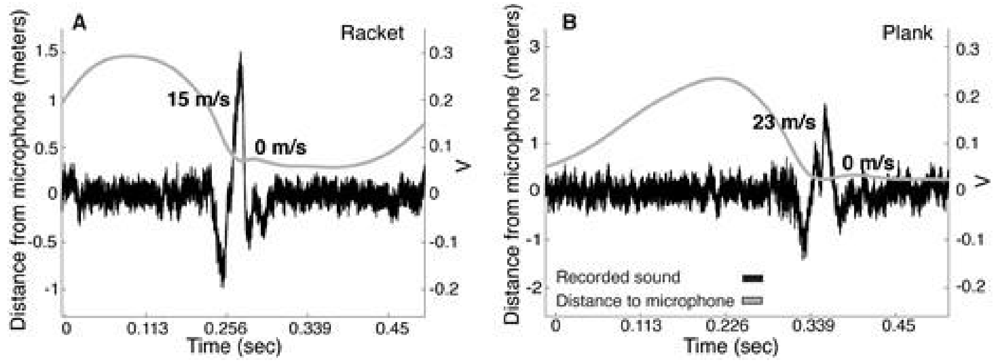
Measurements of the acoustic impulse generated by a single wing flap with a cut-off wing perpendicular to the microphone. Top view of the wing-movement falling within this 2D plane. Distance of the wing to the microphone was 30 cm for all cases. SPL and phase of the sound is given for each direction of wing movement relative to the microphone. Clearly, the phase of the impulse changes with the direction of motion. Note that the direction of the wingbeat was always as in a downstroke. Barn owl data hint that SPL may be higher when recorded from above the owl as it beats its wings, but no such indication comes from the Little Bittern data. The frequency of the impulses generated with the two wings, differing greatly in size, is very similar: 21 and 20 Hz. Online version in color.

Fig. 6

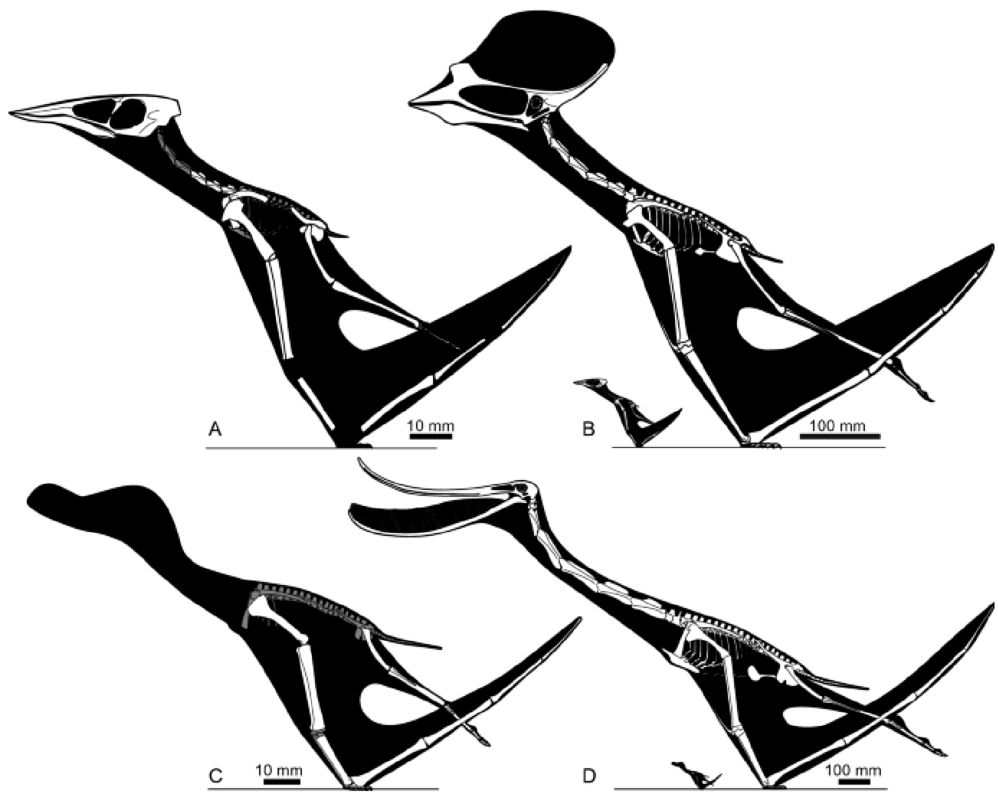
	 **Verification of patterns measured with real wings (Fig. 5) with much simpler shapes: a ping-pong racket and a plank. We used these objects to repeat the motions of Fig. 5 at clock positions of 12, 15, 18, and 21 h to compare the acoustic responses. Above the 12 h response is depicted: the racket or plank moving fast toward the microphone but halting at ~40 cm distance (y-axis) from it (gray line is distance object to microphone). We can observe that when the object is halted (in a natural beating wing: direction reversal), the negative acoustic pressure that has been created flips to positive pressure and then decays rapidly.**
VOCAB: (w/definition)	Dipole acoustics-two monopoles extremely close to each other equal in strength and vibrating at the same frequency just not in phase with each other. -Dipoles and quadrupoles | Sound Waves Morse wavelet- “a family of exactly analytic wavelets. Analytic wavelets are complex-valued wavelets whose Fourier transforms are supported only on the positive real axis. They are useful for analyzing modulated signals, which are signals with time-varying amplitude and frequency”- https://www.mathworks.com/mwaccount/profiles/incomplete?uri=https%3A%2F%2Fwww.mathworks.com%2Fhelp%2Fwavelet%2Fug%2Fmorse-wavelets.html#:~:text=Generalized%20Morse%20wavelets%20are%20a,time%2Dvarying%20amplitude%20and%20frequency. Wing curvature/camber- Camber is defined as the convexity of the curve of an aerofoil from the leading edge to the trailing edge.-https://skybrary.aero/articles/camber Harmonic- a component frequency of an oscillation or wave.-Oxford Languages
Cited references to follow up on	Coward TA. 1928. The wing clapping of the nightjar. Br Birds 22:134–6. Crocker MJ. 2007. Theory of sound—predictions and measurement.

	Handb noise vib control. Hoboken (NJ): Wiley Online Books. Deakin M. 2010. Formulae for insect wingbeat frequency. J Insect Sci 10:1–9. Eitan O, Kosa G, Yovel Y. 2019. Sensory gaze stabilization in echolocating bats. Proc R Soc B Biol Sci 286:20191496. Ellington CP. 1984. The aerodynamics of hovering insect flight. III. Kinematics. Philos Trans R Soc London B Biol Sci 305:41–78. Ennos AR. 1989. The kinematics and aerodynamics of the free flight of some Diptera. J Exp Biol142:49–85.
Follow up Questions	1. How come this model would be successful in modeling smaller animals, what specifically about this model enables this. 2. How come wing area and loading have a greater impact on acoustics than wing length, especially for lower wingbeat rates? 3. How are the single wing flaps in insects different from birds and bats in terms of the acoustics produced? 4. How would the consideration of the doppler effect change the data, especially if these principles were to be applied to airfoils? 5. What about the material of bat wings makes them quieter than birds?

Article #15 Notes: Powered flight in hatchling pterosaurs: evidence from wind form and bone strength

Source Title	Powered flight in hatchling pterosaurs: evidence from wind form and bone strength
Source citation (APA Format)	Naish, D., Witton, M. P., & Martin-Silverstone, E. (2021). Powered flight in hatchling pterosaurs: Evidence from wing form and bone strength. *Scientific Reports*, *11*(1), 13130. https://doi.org/10.1038/s41598-021-92499-z
Original URL	https://www.nature.com/articles/s41598-021-92499-z#citeas
Source type	Journal article
Keywords	Pterosaurs, bone strength, hatchling
#Tags	hatchling

Summary of key points + notes (include methodology)	There are different views regarding how pterosaurs acted in the earliest stages of their lives. This paper looked at two different models, one proposing hatchlings were able to fly through flapping, while the other stated they couldn't until they were half the size of adults. These are tested through the measurements of the flight abilities of young pterosaurs by looking at bone strength, wingspan and aspect ratios, mainly with data from *Pterodaustro guinazui* and *Sinopterus dongi.* They argue that the *Sinopterus* was falsely grouped as an individual taxon. Because the humeri of juveniles and adults is similar, the model where pterosaurs fly later is rejected. Juveniles were also shown to be optimal gliders, and were better suited to cluttered environments vs. older and larger pterosaurs. ● Due to gaps in evidence and records, their earlier stages of pterosaur life is still vastly unknown. ● Studies from the 90's showed that young pterosaurs can be identified based on skeletal proportions and other signs that indicate immaturity. ● Recent evidence has shown that embryonic pterosaurs were similar to adults in bone proportions. ● This indicates they could have been able to fly very early in their lives. ● Some previous studies have challenged this notion, claiming their patterns to be bird-like, with flight possible at half of adult size. ● Birds that chicks can fly the same day as they hatched a specialized and an outlier among birds. ● Two Different models for the earliest phases of pterosaur life are being used, the "flap-early" and "fly-late". ● If capable of flying at young ages, they would occupy more small bodied creature niches, overall decreasing pterosaur diversity. ● Gliding ability is tested in reference to bones support, and hatchling humeral strength is modeled and compared to bones in larger pterosaurs. ● Models based on four specimens of two taxa, one had a wingspan of 0.24 m, the other 0.29 m. ● One pterosaur represented juveniles due to overall lack of development. ● However, it is likely this is a misidentified juvenile tapejarid. ● The development, size, ossification of different bones is looked at to determine the overall age of the pterosaur. ● IVPP V-14377 is a young juvenile and has anatomical characteristics, meets predictions of tapejarid scaling trends, occurs in a formation that gives many tapejarid remains ● Existing studies show significant correlations between wind loading and glide performance, meaning strong gliding performances represent good relationships between area, mass, and gravity. ● Flight v. 1.24 was used to model glide performance.

	● Maximum lift coefficient was set to 2.2 (greatest from living birds). ● Pterosaur humeri bone was looked at for strength as the primary limb for power in taking off. ● Cantilever-style loading was used to model bone stress. ● It is suggested that pterosaurs were better gliders than modern day animals. ● The overall glide performance is connected with a decreased wing loading. ● The hatchling pterosaurs are better adapted for sustained flight. ● The hatching humeri are proportionate to body weight, making them some of the strongest for pterosaurs. ● Same bone density for hatching and adult pterosaurs was assumed. ● Their strength is due to the skeletal matrix being similar to larger pterosaurs, and low body masses for minimal loading. ● While juveniles did share fundamental elements of skeletal structure, there was also shown to be differences due to changes in size from the start to end of their lives.
Research Question/Problem/ Need	How can it be determined when juvenile pterosaurs actually started to fly based on different models?
Important Figures	 Figure 1: An image of skeletons used in the study. (a) *Sinopterus dongi,* (b) *Sinopterus dongi* compared to an adult which is bases on the *Sinopterus benxiensis*, (c) *Pterodaustro guinazui* hatchling, (d) hatcling compared to an adult, white represents well-represented bones, gray indicates it was

difficult to reconstruct based on fossils.

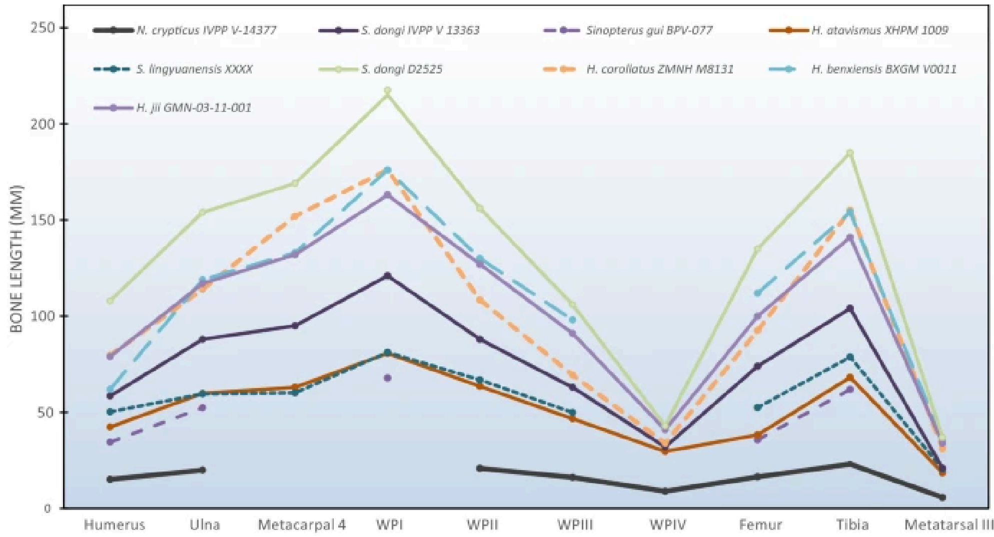


Figure 2: The different limb ratios of Juifotanf tapejarid specimens. These metrics were taken from papers of the listed taxa. This graph was used to scale different bone sizes.

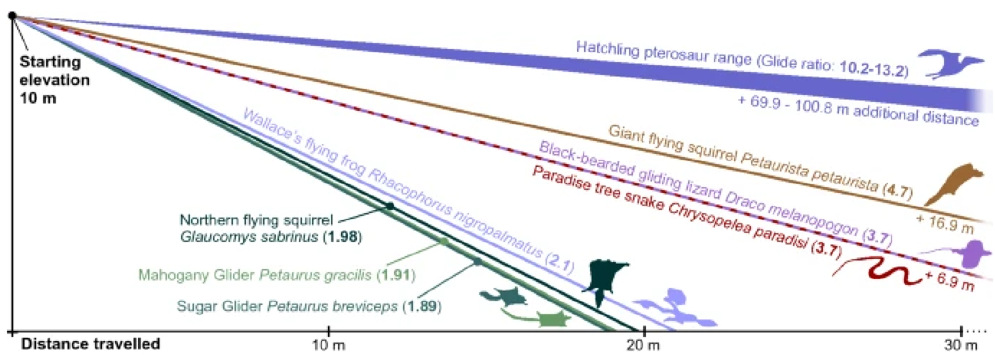
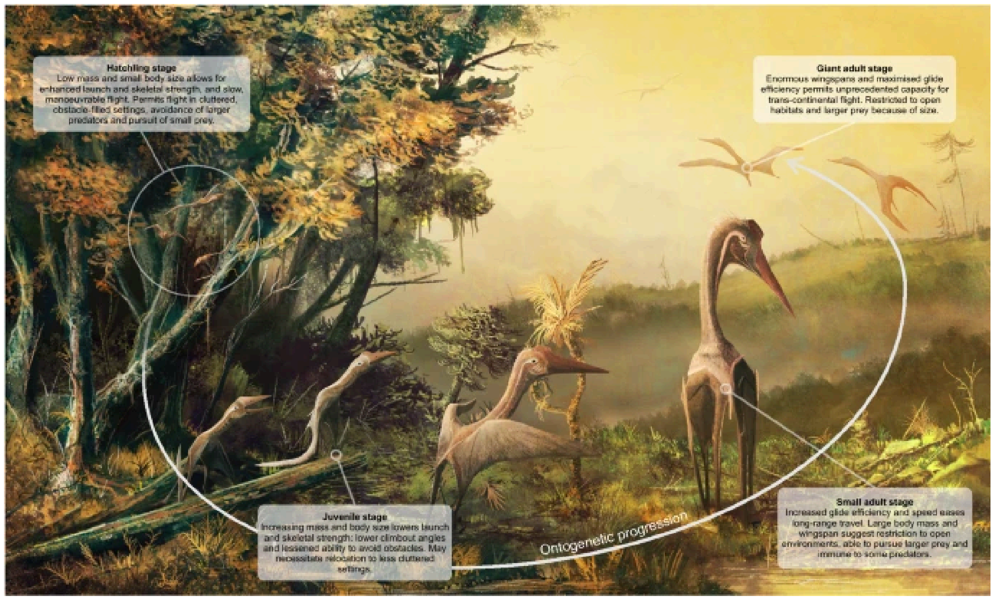


Figure 3: Best glide angles of gliding tetrapods and hatchling pterosaurs. Hatchling pterosaur glide angles represent the range of results obtained for all hatchlings modeled in this study (both minimum sink and best glide values).

	 Figure 4: Visual summary of how basic, size-dependent flight parameters (wing loading, wingspan and aspect ratio) could have influenced pterosaur ecology throughout ontogeny. The animals shown here are giant azhdarchids, species which likely had the largest ontogenetic mass differentials of any pterosaurs (see text) and thus potentially the broadest ecological range across their various growth stages. Azhdarchids were primarily terrestrial pterosaurs, which is reflected in this figure, though the environments and points made here are generalized: they do not expressly pertain to any azhdarchid taxon. Ontogenetic niche exploitation may have differed in other environments.
VOCAB: (w/definition)	1. Taxa-taxonomic group of any rank, such as species, family, or class. -Oxford Languages 2. Osteological - relating to the study of structure and function of the skeleton and bone related structures - Oxford Languages. 3. Ossification - natural process of bone formation. -Merriam-Webster 4. Precocial - young bird or animal hatched or born in an advanced state and is able to feed and move itself independently almost immediately.
Cited references to follow up on	Bennett, S. C. The ontogeny of *Pteranodon* and other pterosaurs. *Paleobiology* 19, 92–106 (1993). Bennett, S. C. A statistical study of *Rhamphorhynchus* from the Solnhofen Limestone of Germany: Year-classes of a single large species. *J. Paleontol.* 69, 569–580 (1995). Codorniú, L., Chiappe, L. & Rivarola, D. Neonate morphology and development in pterosaurs: evidence from a ctenochasmatid embryo from

	the Early Cretaceous of Argentina. In *New Perspectives on Pterosaur Palaeobiology* Vol. 455 (eds Hone, D. W. E. *et al.*) 83–94 (Geological Society London Special Publications, 2018). Wang, X. *et al.* Egg accumulation with 3D embryos provides insight into the life history of a pterosaur. *Science* 358, 1197–1201 (2017). Heij, C. J., Rompas, C. F. E. & Moeliker, C. W. The biology of the Mollucan megapode *Eulipoa wallacei* (Aves, Galliformes, Megapodiidae) on Haruku and other Mollucan Islands; part 2. *Deinsea* 3, 1–120 (1997).
Follow up Questions	1. How would the results of this experiment have changed without assuming juveniles and adults have the same bone density? 2. How did the niche of a pterosaur change as it developed? 3. How did the different environments pterosaurs were in due to different ages affect their adaptations? 4. How can pterosaurs be so conservative through their lives, meaning they are similar when they are juveniles to when they are adults living such distinct lives?

Article #16 Notes: Wind turbine nose and its mitigation techniques: A review

Source Title	Wind turbine noise and its mitigation techniques: A Review
Source citation (APA Format)	Deshmukh, S., Bhattacharya, S., Jain, A., & Paul, A. R. (2019). Wind turbine noise and its mitigation techniques: A review. *Energy Procedia*, *160*, 633–640. https://doi.org/10.1016/j.egypro.2019.02.215
Original URL	https://pdf.sciencedirectassets.com/277910/1-s2.0-S1876610219X00065/1-s2.
Source type	Journal Article
Keywords	Wind turbine noise, trailing edge noise, tip noise, noise reduction
#Tags	trailing edge noise
Summary of key points + notes (include methodology)	Multiple different aerodynamic sources of noise and ways to mitigate them are discussed in this article. Trailing edge noise and inflow turbulence noise are the primary cause of the low frequencies of noise, while the tip creates

	the higher frequencies. Many different methods for noise reduction were examined. Serrated edges, trailing edge brushes, porous trailing edges were methods that yielded successful results. Work still needs to be done to mitigate inflow turbulence noise. Biomimicry can be used as inspiration for leading edge serrations. Most of the tests and simulations conducted still need to be tested in the field at full-scale. ● Wind turbines are being increasingly installed due to lack of energy ● As they get closer to residencies, there are complaints due to noise, and can cause annoyance and sleep disturbance. ● 4.4% of the total global energy in electricity comes from wind turbines ● In 2017, the wind energy generated rose by 11% ● As wind turbines grow in use, quieter and more efficient turbines are needed. ● Two types of noise, aerodynamic and mechanical ● Mechanical noise is caused by the mechanical components in a turbine, and creates a tonal noise,and is the more harmful type of noise. Modern wind turbines have mostly solved this problem. ● Aerodynamic noise is from the interaction of air and the blades, now is the larger source of noise. ● Inflow turbulence noise- mainly from leading edge, broadband noise, depends on atmospheric pressure, turbulence intensity, and turbulence length scale. ● Turbulent boundary layer=trailing edge noise, broadband-most of where noise comes from, turbulent boundary layer and trailing edge of airfoil, stronger closer to the tip. ● Tip vortex- made because of cross flow made from pressure difference between pressure side and suction side.Works in the same way as trailing edge noise, and large source of irritation. ● Blunt trailing edge noise-tonal noise, depends on shape of trailing edge,-mitigated with sharp trailing edge. ● Past a specific angle of attack, the blade is stalled causing flow separation, unsteady +broadband noise, mitigated by avoiding stall conditions ● Laminar boundary noise-Reynolds number $< 10^6$, flow of both sides can remain laminar up to trailing edge ● Tubercles on Humpback whales flippers with sinusoidal leading edge-reduces tonal noise. ● Leading edge serrations have been looked at on barn owls as well. ● Noise is scattered more effectively when the path of turbulent sections is perpendicular to the trailing edge. ● Trailing edge brushes can reduce trailing edge noise. ● A shark tip reference was able to reduce tip noise by 7%, with a loss of power of 3%.
Research Question/Problem/	What are the different sources of noise from wind turbines, and how can

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<tr><td>Need</td><td>they be mitigated?</td></tr>
<tr><td>Important Figures</td><td>

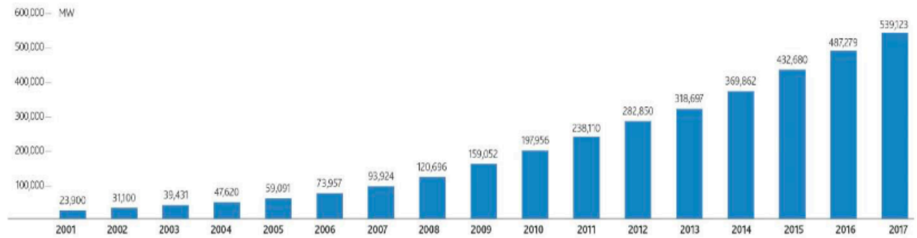

Fig. 2. Global cumulative installed wind capacity (2001-2017) [6]

Figure 1: Represents the total installed wind capacity globally from 2001-2017. It shows an increase in total global wind energy.

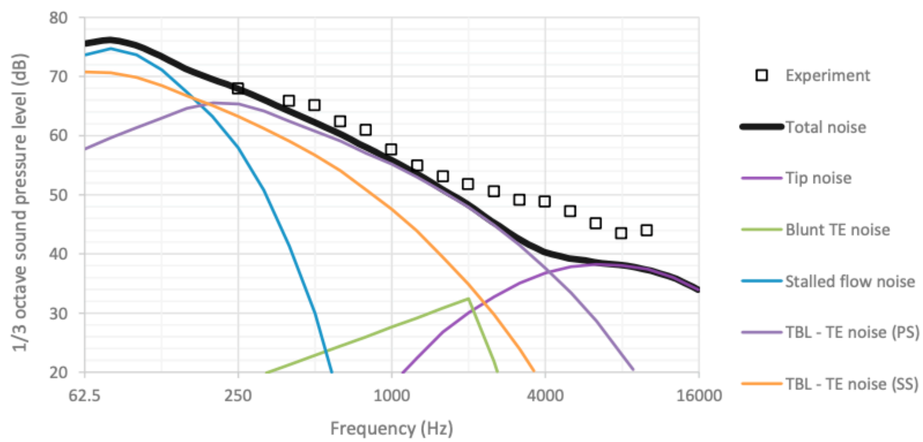

Fig. 3. Contribution of individual sources to noise from a wind turbine blade (reference tip) [7]

Figure 2: Each individual component of a blade that creates noise, and how much it contributes to the total noise.

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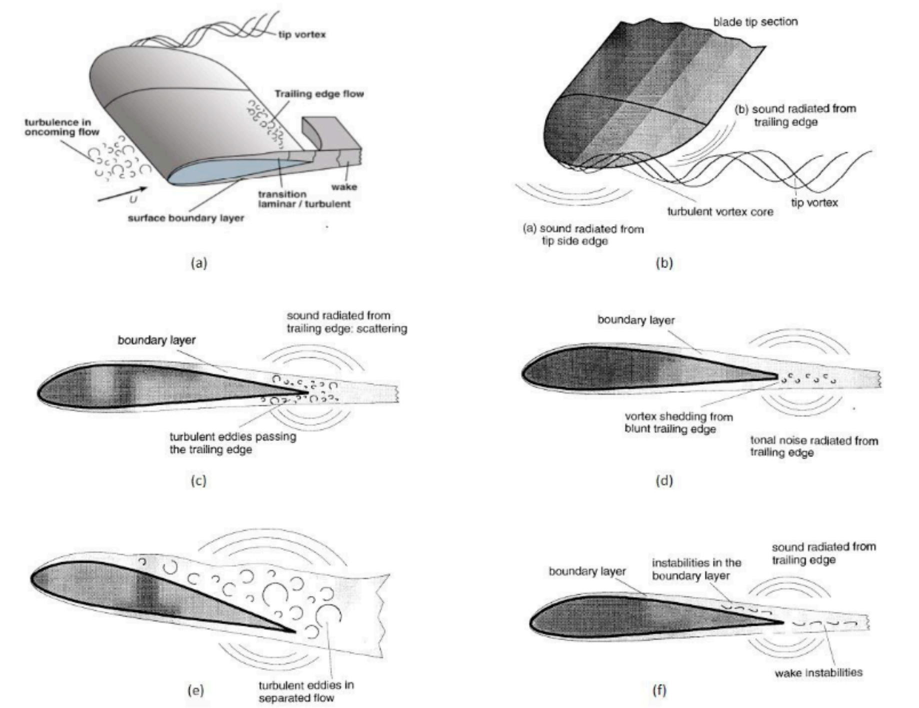


Fig. 4. (a). Flow over the outer section of a wind turbine blade; (b - f) Airfoil self-noise mechanisms [7]

Figure 3: (a). Shows the flow over the outer section of a wind turbine blade. (b-f) show different individual airfoil contributions to noise.

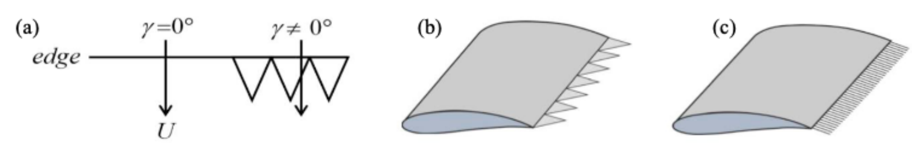


Fig. 6. (a, b) Trailing edge serrations; (c) Trailing edge brushes [10]

Figure 4: Represents how the optimal scattering of noise occurs when the path or turbulent eddies is perpendicular to the trailing edges. Then, it shows trailing edge serrations (b) and trailing edge brushes (c) .

VOCAB: (w/definition)

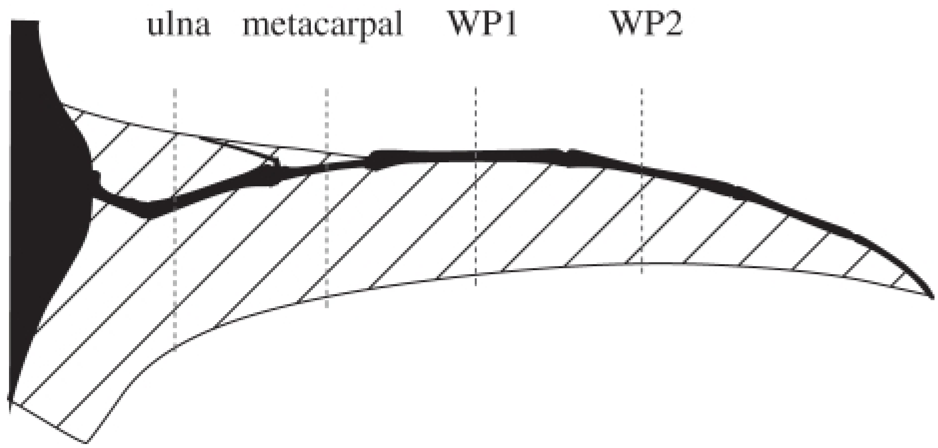
1. Mechanical noise- noise in a wind turbine generated by various moving components present in the nacelle like gearbox, generator, cooling fans and other auxiliary devices.
2. Inflow turbulence noise- caused due to interaction of blade surface, especially the leading edge, with the oncoming atmospheric turbulence.
3. Turbulent boundary layer-also known as trailing edge noise, is the dominant source of broadband noise in wind turbines, and occurs due to the interaction of the turbulent boundary layer with the sharp trailing edge of an airfoil.

	4. Blunt trailing edge noise- Causes Von Karman type vortices resulting in tonal noise. This noise is dependent on the shape of the airfoil. 5. Stalled flow noise - past a certain angle of attack, the blade is stalled leading to flow separation. Can cause sound radiation from the trailing edge, to the entire cord itself.
Cited references to follow up on	Dai K, Bergot A, Liang C, Xiang WN and Huang Z. Environmental issues associated with wind energy - A review. Renewable Energy 2015;75, pp. 911-921 [2] Council of Canadian Academies. Understanding the Evidence: Wind Turbine Noise. Ottawa (ON): The Expert Panel on Wind Turbine Noise and Human Health, Council of Canadian Academies 2015. [3] Pedersen E and Waye KP. Perception and annoyance due to wind turbine noise—a dose–response relationship. The Journal of the Acoustical Society of America 2004;116(6), pp.3460-3470. [4] Pedersen E and Waye KP. Wind turbine noise, annoyance and self-reported health and well-being in different living environments. Occupational and Environmental Medicine 2007;64(7), pp.480-486. [5] BP Statistical Review of World Energy, 67th edition 2018. [6] GWEC. Global Wind Report. GWEC 2018. [7] Wagner S, Bareiß R and Guidati G. Wind turbine noise. Berlin: Springer 2012.
Follow up Questions	1. What is the specific angle of attack that wind turbine blades stall at? 2. What specific designs have been inspired by barn owls regarding sinusoidal serrations? 3. How can inflow turbulence noise be mitigated? 4. What was the specific characteristic of the shark that was referenced for the tip of a wind turbine blade?

Article #17 Notes: Flight in slow motion: aerodynamics of pterosaur wing

Source Title	Flight in slow motion: aerodynamics of pterosaur wing
Source citation (APA Format)	Palmer, C. (2011). Flight in slow motion: Aerodynamics of the pterosaur wing. *Proceedings of the Royal Society B: Biological Sciences*, *278*(1713), 1881–1885. https://doi.org/10.1098/rspb.2010.2179

Original URL	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3097835/
Source type	Journal article
Keywords	Flight, wing membrane, pterosaurs, aerodynamics
#Tags	Wing membrane
Summary of key points + notes (include methodology)	Pterosaurs and how they flew, especially with some of their sizes has been a long unanswered question. Flight data from the past relied on the aerodynamic data available at the time, which was limited and unrepresentative. In this study, wind tunnel tests for a variety of possible wing sections for pterosaurs to be able to obtain actual quantities was conducted. The drag and maximum lift coefficients proved to be larger than originally thought, indicating that large pterosaurs may have been less aerodynamically efficient to enable slower flight. Pterosaur wings were adapted to be flying, soaring, and landing at low speeds, not marine style dynamic soaring. Low flight speeds enabled them to avoid serious impacts that would have damaged their thick bones. *Notes may not be paraphrased ● Pterosaurs had flexible membrane wings supported by one finger. ● We don't know how exactly the membrane was connected to the bone. ● Because of gaps in knowledge, a variety of 2D models were made and tested under low speeds in a wind tunnel with a generic 5.8 m wingspan. ● Made from thin sheets of carbon fiber ● Wings are made from two regions, the proximal region where the propatagium was present and the distal region where it wasn't. ● Proximal region was modeled with the wing bone (ulna), and faired and unfaired geometries represented muscles. ● The membrane was made from latex, and was reinforced with cotton fibers. ● As a method of confirming the tests, the cambered plate model results were fared against the results published in another paper. Showed it was overall similar in shape and trends. ● They analyzed results by looking at the relationships between the lift coefficient and drag coefficient. Used to calculate flight performances of a 3D pterosaur with a wing area of 2.2 m squared, mass 13.9-32 kg. ● Used then to calculate glide polar curve. ● Calculated parasitic drag and polar curve. ● Polar curve was solved for the airspeed vector, where you can derive the horizontal and vertical components.

	• Max of the curve is the minimum sink point. • Point tangent to line through axis is mac aerodynamic efficiency, and max range • Ulna at 40 percent of wing cord lowered max lift but didn't increase minimum drag, 20% had greater reduction, but was still small. • Drag increased between the two shapes, no effect on max lift, phalanx on dorsal side of wing reduced section performance, increased drag and max lift, • Larger the bone relative to the width of the wing the bigger the drag,, max lift coefficients were still higher for flexible sections of wing, greater than that of birds.
Research Question/Problem/ Need	What was the true nature of how pterosaurs flew?
Important Figures	 Figure 1: Generalized shape of the wing of a large ornithocheirid pterosaur. Redrawn from recent reconstructions [16,17,46], and showing the locations of the wing sections that were tested and the extent of the wing membrane assumed (cross-hatched area).

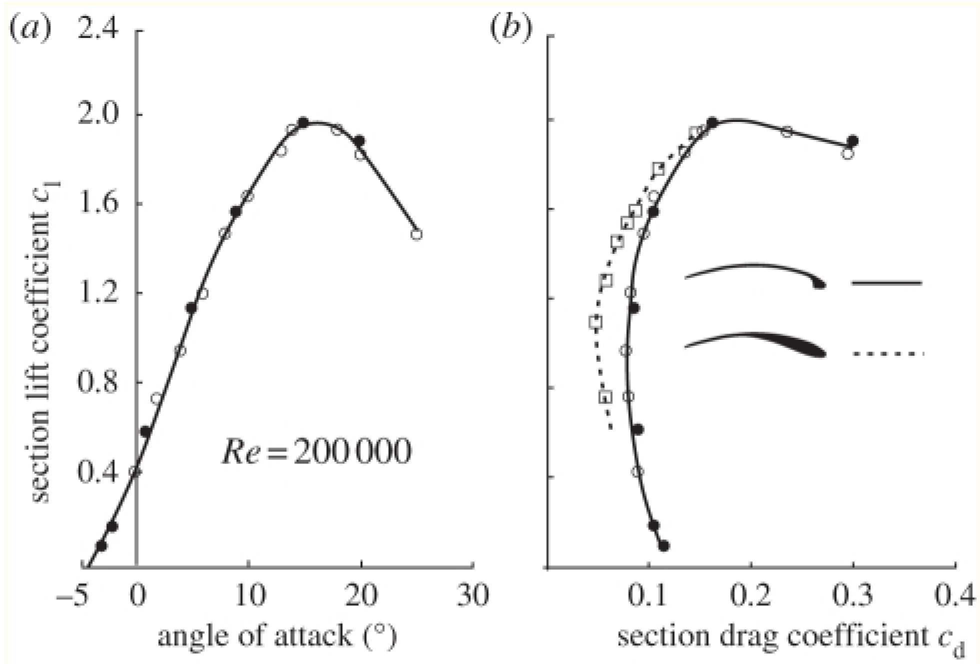


Figure 2: Typical wind tunnel test results at *Re* = 200 000. (*a*) Variation of section lift coefficient (c_l) with angle of attack for WP2 wing bone section. Open circles: results with increasing angle of attack. Filled circles: results for decreasing angle of attack. The closeness of these results demonstrates good test repeatability and absence of hysteresis effects. (*b*) Effect of section fairing on c_l : c_d for the WP2 wing section. The extensive fairing significantly reduces the minimum drag coefficient but has no effect on maximum lift coefficient.

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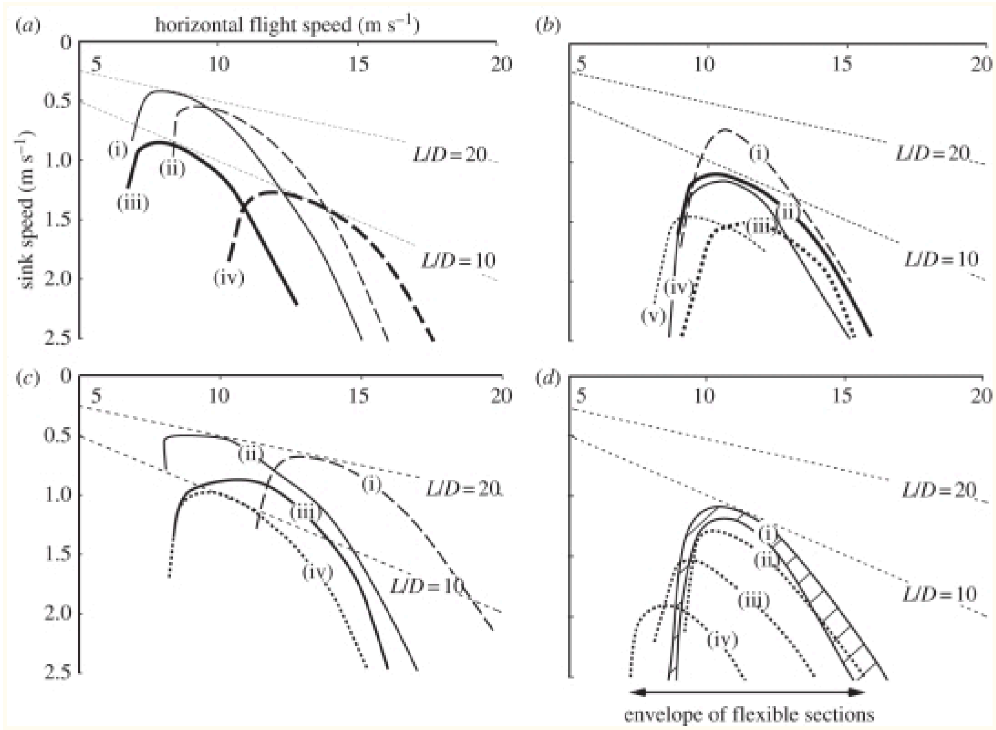

Figure 3:Polar glide curves. (*a*) Comparison with results from previous studies ((i) [10]; (ii) [12]), with results from present tests (WP1 medium camber section) at two extremes of mass ((iii) and (iv)). The WP1 wing has only half the aerodynamic efficiency (*L*/*D* ratio) and almost twice the sink rate of the earlier estimates. (*b*) Effect of different wing bone sizes and shapes: (i) section with no bone; (ii) small WP1; (iii) large WP1; (iv) small WP2; and (v) large WP2. The WP1 phalanges move the polar curve downwards with increasing size, resulting in little change in the optimum flight speed but a large increase in the sink rate. The WP2 phalanges have similar effects, but because they increase both drag and the maximum lift coefficient, the glide polar moves a little to the left, extending the low-speed flight envelope. (*c*) Potential performance of an optimized wing section: (i) 417a section used in earlier reconstructions; (ii) optimized modern S1223 laminar flow aerofoil section [48]; (iii) WP2 faired with XFOIL designed fairing; and (iv) small WP2 only. The two aerofoil sections give similar peak efficiencies of 20 : 1, but the S1223 section maintains good performance to higher values of lift coefficient, shifting the polar curve to the left. (*d*) Effect of flexibility: (i) envelope of rigid sections with same bone depth as flexible section, and (ii)–(iv) the flexible section with increasing membrane slackness.
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<td>VOCAB: (w/definition)</td>
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1. Glide forward curve-the variate of the sink speed with forwards speed.
2. Proximal region- region of the pterosaur wing where a propatagium was located.
3. Distal region - region of the pterosaur wing where the propatagium wasn’t present.
4. Ulna- first wing bone on the wing of a pterosaur.
5. Fairing - structure on the exterior on an aircraft or boat to reduce drag. -Collins English Dictionary
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<td>Cited references to follow up on</td>
<td>1. Wellnhofer P. 1991. The illustrated encyclopedia of</td>
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	pterosaurs. London, UK: Salamander [Google Scholar] 2. Unwin D. M. 2005. *The pterosaurs: from deep time*. New York, NY: Pi Press [Google Scholar] 3. Kellner W. A., Wang X., Tischlinger H., Campos D., Hone D. W. E., Meng X. 2009. The soft tissue of *Jeholopterus* (Pterosauria, Anurognathidae, Batrachognathinae) and the structure of the pterosaur wing membrane. *Proc. R. Soc. B* **277**, 321–329 10.1098/rspb.2009.0846 (doi:10.1098/rspb.2009.0846) [PMC free article] [PubMed] [CrossRef] [Google Scholar] 4. Marchaj C. A. 1979. *Aero-hydrodynamics of sailing*. London, UK: Adlard Coles Nautical [Google Scholar] 5. Claessens L. P. A. M., O'Connor P. M., Unwin D. M. 2009. Respiratory evolution facilitated the origin of pterosaur flight and aerial gigantism. *PLoS ONE* **4**, e4497. 10.1371/journal.pone.0004497 (doi:10.1371/journal.pone.0004497) [PMC free article][PubMed] [CrossRef] [Google Scholar] 6. Frey E., Riess J. 1981. A new reconstruction of the pterosaur wing. *N. Jb. Geol. Paläont. Abh.***161**, 1–27 [Google Scholar]
Follow up Questions	1. Were there any other prehistoric animals related to pterosaurs that also flew slowly, is this indicated by bone structure? 2. How might aerodynamic analysis of the pterosaur wing change based on how the skin was attached to the bone? 3. Did pterosaurs evolve over time to fly slowly, if so are there older ancestors that have been found that might have flown faster? 4. How do pterosaur wings fair against modern day bird wings of the same size in terms of overall force generated?

Article #18 Notes: Evolutionary and Ecological Correlates of Quiet Flight in Nightbirds, Hawks, Falcons, and Owls

Source Title	Evolutionary and Ecological Correlates of Quiet Flight in Nightbirds, Hawks, Falcons, and Owls
Source citation (APA Format)	Clark, C. J., LePiane, K., & Liu, L. (2020). Evolutionary and Ecological Correlates of Quiet Flight in Nightbirds, Hawks, Falcons, and Owls. *Integrative and Comparative Biology*, *60*(5), 1123–1134. https://doi.org/10.1093/icb/icaa039
Original URL	doi.org/10.1093/icb/icaa039
Source type	Journal Article
Keywords	Nightbirds, Hawks, Falcons, Owls
#Tags	Nightbirds
Summary of key points + notes (include methodology)	Different bird species such as nightbirds, owls, and hawks have evolved to obtain certain adaptations to reduce their sound emissions. One example is the presence of velvety feathers in these birds. There are two opposing hypotheses, the stealth hypothesis and self-masking hypothesis. The stealth hypothesis proposes velvety feathers disabled other animals from hearing these birds, while the self-masking hypothesis proposes it enables birds to hear themselves. After studies were conducted on the different bird species, there was evidence supporting both hypotheses. ● There are two hypotheses as to why sound structions in birds have been reduced because of evolution, one being it ensures other animals don't detect them, the other being the self-masking hypothesis proposes it allows animals to hear themselves more effectively. ● Owls, hawks, and nightbirds have adaptations of a velvety coat on their feathers. ● The velvet is longer and is further developed in areas that tend to rub against other feathers more. ● Decreases broadband friction noise ● It was tested whether self-masking enabled more accurate

	predictions as to which species evolved. ● Echolocation didn't have evidence to support it being a main factor. ● Examples were the oilbird and glossy swiftlet both utilizing echolocation but neither having velvety feathers. ● Both hypotheses were supported by phylogenetic least squares, meaning these features of each animal didn't settle the dispute between the two. ● Certain species of night birds will eat insects that fly mostly silently, which could indicate that the presence of velvety feathers allows these nighbirds to eat these insects, implying they are quiet enough to not be detected. ● Self-emaksing is supported by frogmouths (a certain type of nightbird) having more velvet, indicating they might hunt animals using their hearing. ● This is supported by hawks, as the species that have the most velvet likely hunt using their hearing. ● Contradictingly, there is also velvet to a lesser extent in hawks that don't use their ears, supporting the other hypothesis. ● An example of this si the American kestrel as it doesn't use its hearing to hunt and its velvet aids it in flying slowly, supporting the stealth hypothesis. ● All the sampled owls all had lots of velvet, and owls have been shown to be quiet.
Research Question/Problem/ Need	Does the presence of velvet on the wing feathers of hawks, falcons, nightbirds, and owls evolve to reduce self masking?

Important Figures

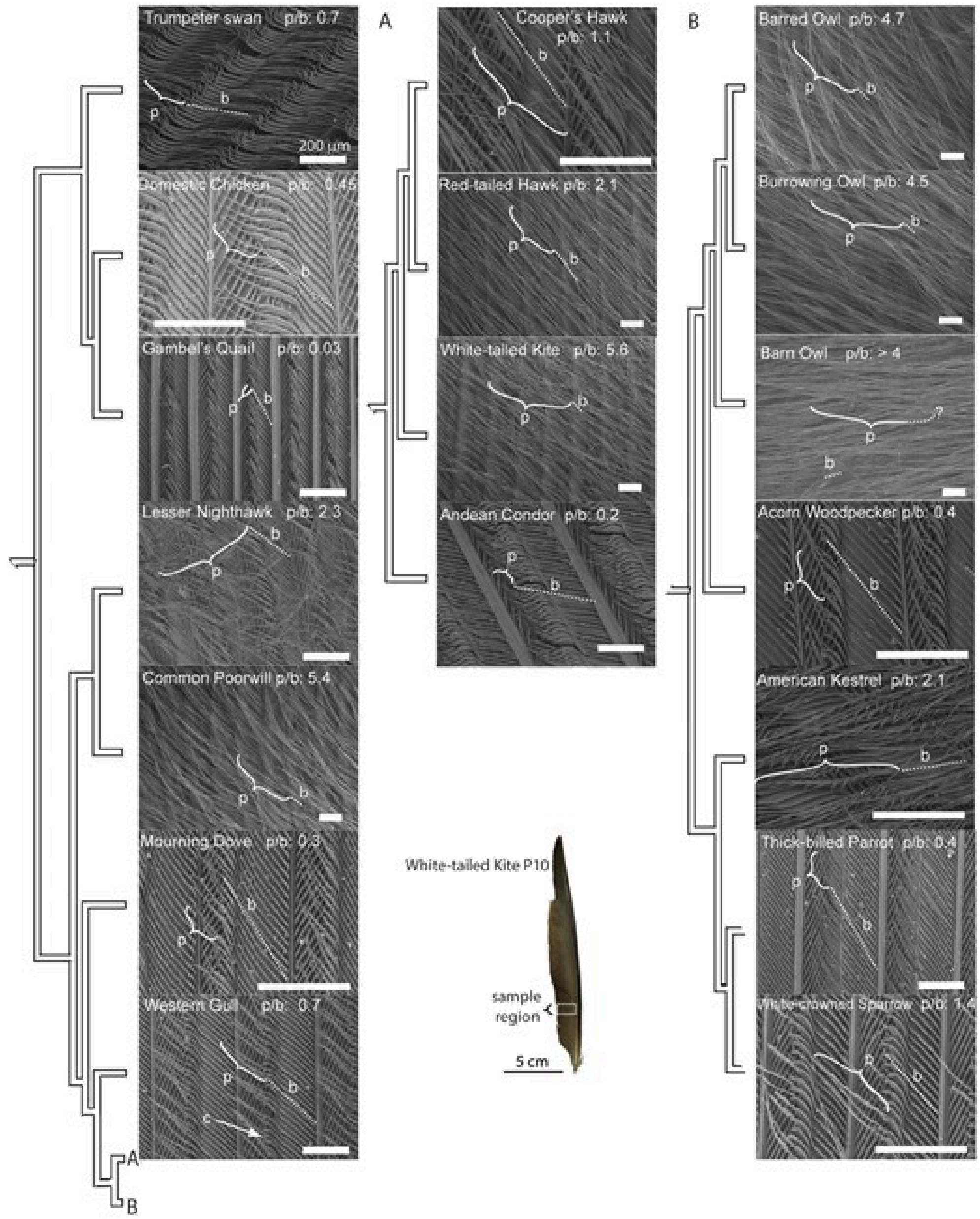


Figure 1: Images of the dorsal surface of the proximal vane of an outer primary of 18 species of birds, showing pennulae length relative to the length of the distal barbule. Some species shoe "fastening barbules" or cilia.

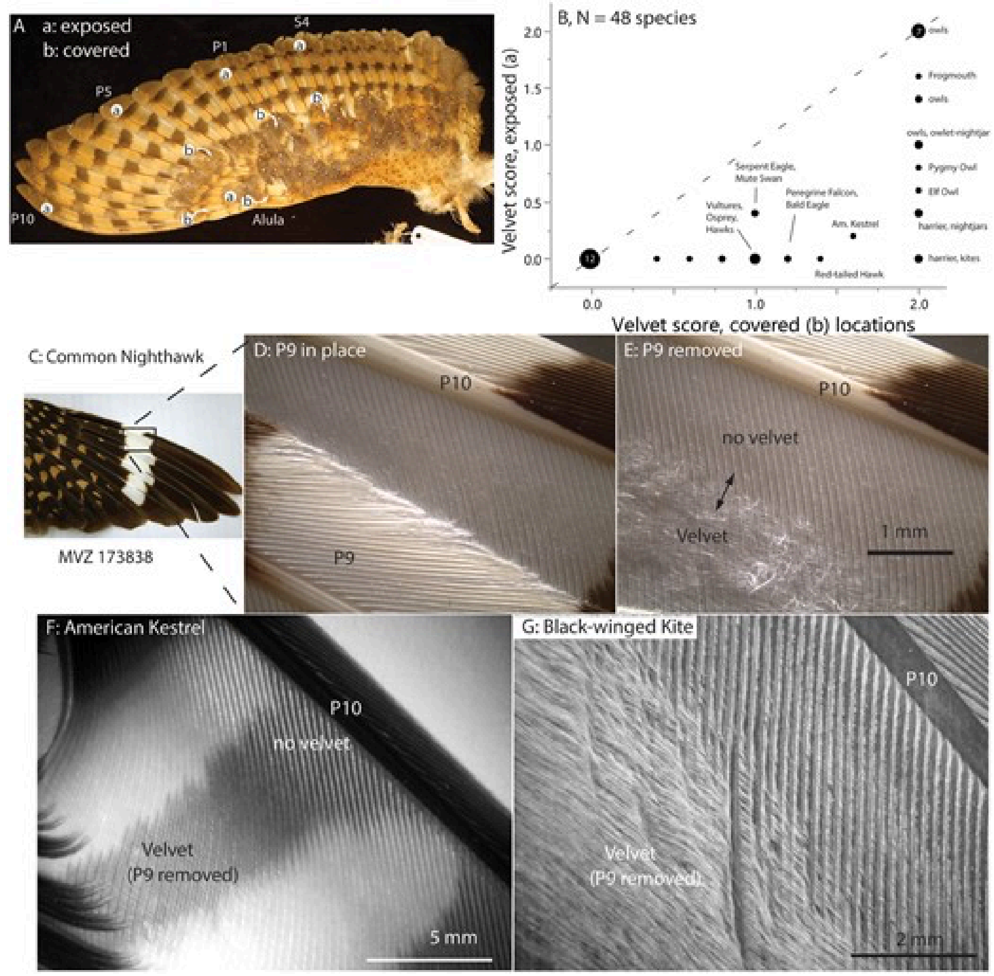
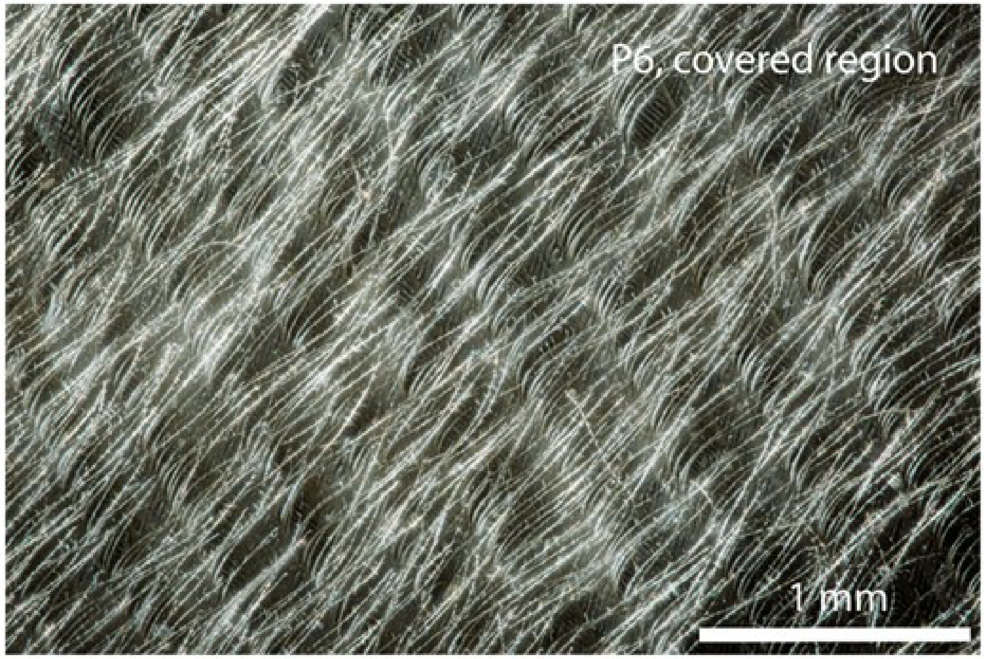


Figure 2: Velvet tended to be longer in areas where wing feathers overlap than in locations exposed to the boundary layer. (**A**) Sample locations for measuring the presence of velvet, showing exposed (a), and covered (b) locations. In each case, for the covered sample locations, the adjacent overlaying feather(s) were gently lifted to expose the measurement location. Pictured: barn owl (*Tyto alba*) wing. (**B**) Average velvet score of covered ("b") against exposed ("a") locations, for 48 species. Dashed line is 1:1; no species fell above the line. Dot size proportional to number of species with that score. (**C**) Wing of common nighthawk (*Chordeiles minor*, a nightjar within Nightbirds). (**D**) Dorsal surface of P10 that is exposed to airflow has minimal velvet. (**E**) P10 in the region that is underneath P9 has extensive velvet. (**F, G**) American kestrel (BM 32499) and black-winged kite (BM 66216) show the same pattern (P9 has been lifted away to show covered region in each).

	 Figure 3: Velvet on a covered region of buffy fish-owl.
VOCAB: (w/definition)	1. Phylogenetic-Relating to the evolutionary development and diversification of a species or group of organisms, or of a particular feature of an organism. 2. Barbules-a minute filament projecting from the barb of a feather. -Oxford Languages 3. Echolocation-the location of objects reflected by sound, particularly used by specific animals. -Oxford Languages 4. Dorsal-relating to the back or posterior of a structure. - Medical Definition of Dorsal - RxList
Cited references to follow up on	Mindell DP , Fuchs J , Johnson JA. 2018. Phylogeny, taxonomy, and geographic diversity of diurnal raptors: falconiformes, accipitriformes, and cathartiformes. In: Sarasola JH , Grande JM , Negro JJ, editors. *Birds of prey: biology and conservation in the XXI century*. Cham: Springer International Publishing. p. 3–32. Google Scholar Google Preview Find in my library WorldCat COPAC Moreno-Rueda G. 2017. Preen oil and bird fitness: a critical review of the evidence. *Biol Rev* 92:2131–43. Google Scholar Crossref Find in my library

	PubMed WorldCat Müller W , Patone G. 1998. Air transmissivity of feathers. *J Exp Biol* 201:2591–9. Google Scholar PubMed Find in my library WorldCat Negro JJ , Pertoldi C , Randi E , Ferrero JJ , López-Caballero JM , Rivera D , Korpimäki E. 2006. Convergent evolution of *Elanus* kites and the owls. *J Rapt Res* 40:222–5. Google Scholar Crossref Find in my library WorldCat Paradis E Schliep K. 2019. Ape 5.0: an environment for modern phylogenetics and evolutionary analyses in R. *Bioinformatics* 35:526–8. Google Scholar Crossref Find in my library PubMed WorldCat Rice WR. 1982. Acoustical location of prey by the marsh hawk: adaptation to concealed prey. *Auk* 99:403–13. Google Scholar Crossref Find in my library WorldCat Rodríguez A , Siverio F , Barone R , Rodríguez B , Negro JJ. 2009. An overlooked cost for the velvety plumage of owls: entanglement in adhesive vegetation. *Wilson J Ornithol* 121:439–41.
Follow up Questions	1. Is there more evidence in support of the stealth hypothesis of the self-masking hypothesis? 2. Are birds with velvety feathers right now more likely to evolve to use their hearing more for survival? 3. How much power efficiency is lost as a result of velvety feathers? 4. Are velvety feathers the primary cause of noise reduction in some species of birds?

Article #19 Notes: Bat flight: aerodynamics, kinematics and flight morphology

Source Title	Bat flight: aerodynamics, kinematics and flight morphology
Source citation (APA Format)	Hedenström, A., & Johansson, L. C. (2015). Bat flight: Aerodynamics, kinematics and flight morphology. *Journal of Experimental Biology*, *218*(5), 653–663. https://doi.org/10.1242/jeb.031203
Original URL	https://doi.org/10.1242/jeb.031203
Source type	Journal Article
Keywords	Bat flight, Aerodynamics, Kinematic, Flight morphology
#Tags	Bat flight
Summary of key points + notes (include methodology)	Bats have evolved to obtain the ability of powered flight over millions of years. Modern day bats are efficient when flying, and utilizing particle image velocimetry wake vortices, this study finds the magnitude and time forces related to aerodynamics. A wide range of speeds entails lift and thrust on a downstroke, and the upstroke function adjusts to the forward flight speed. Bats are able to hover and fly slowly using a leading edge cortex to make the lit stronger. Many features of the abt wing itself promote optimal flight. Bats are less efficient than birds aerodynamically, but are better at maneuvering. The aerodynamic performance of a bat wing correlates to kinematics. ● Bats have evolved to have the ability of powered flight over millions of years. ● Bats echolocate, allowing them to avoid objects well in the dark. ● Flapping motion and overall speed yields net speed of the airflow above the wing at a given angle of attack. ● Different characteristics of the wing, being thickness, camber, surface texture are factored into the lift coefficient. ● Because bat wings flap and flex, blade lament theory is impractical.

	● Cortices shed by wings into the wake of bats are measured using particle image velocimetry. ● Root vortices mainly occur during the downstroke,and upstroke in some pieces. ● A reverse vortex loop is the feature of the wake that bats possess uniquely when moving at relatively high speeds. ● As flight slows, it decreases and disappears. ● Thrust and negative lift are made during upstroke at high speeds. ● Studies in wind tunnels and wing flow show that bats flying slowly have the presence of LEV in small Palla's long-tongued bats, and other species. ● During downstroke at low speed, smaller long nose bats have LEv at edge of wings morphological ventral side ● It is expected that most bats can hover and fly slowly using LEVs to increase lift. ● #D characterization also shows horizontal thrust and drag. ● Flight speed of minimum angular velocity of a wing is directly related to flight muscle contraction speed therefore the efficiency of the muscles follows along with the max flight speed. ● Aerodynamic efficiency is also measured as span efficiency, being the ratio of the ideal induced power and measured induced power. ● Birds show higher flight efficiency than bats because the bird body generates more lift than the bat body. ● BAts have generally a wider range of possible adjustments morphologically, meaning they could control it to meet aerodynamic demands. ● Bat skin 4-10 times thinner than typical mammal, ● Aerodynamic loading is a result of the tensioning membrane ● Trailing edge is stretched, along with the membrane. ● The skin between the legs of bats, aerodynamic purpose not quite known. ● Ears mostly contribute to drag and echolocation ● It is suggested there is smaller morphospace occupied by bats ● Bats typically have lower wing loadings than birds, and better moving capacity. ● Bats have higher degrees of kinematics compared to birds ● To control forces, wing beat frequency decreases, stroke panel angle increases, wing area decreases during the upstroke. ● Kinematic factors are associated with differences in the lift coefficient ● The power for a bat to flight is a U-curve when put agains airspeed.
Research Question/Problem/ Need	How does the flight of a bat work in terms of aerodynamics, kinematics, and flight morphology?

Important Figures

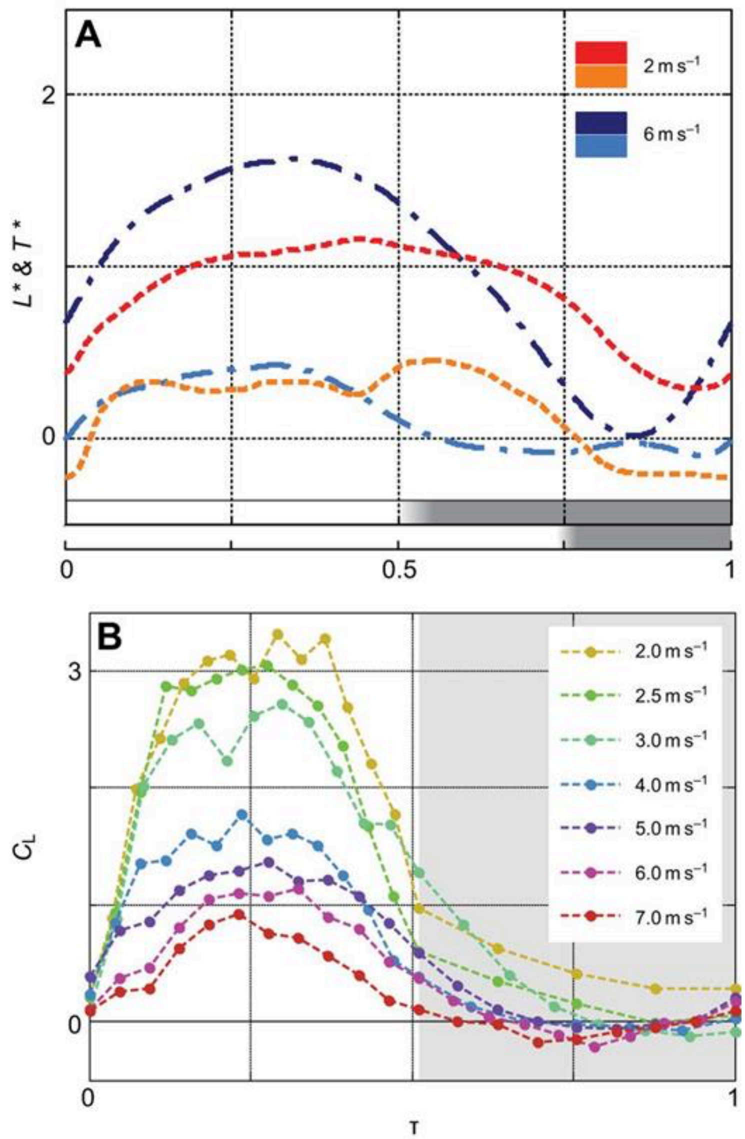


Figure 1: **Force and lift coefficient of lesser short-nosed bat *Leptonycteris yerbabuenae* at different flight speeds during normalized wingbeats (0<τ< 1).** (A) Normalized lift (*L*) (dark blue and red) and thrust (*T*) (light blue and orange). Shaded areas below the graph indicate the upstroke with upper scale for fast (6 m s^{-1}) flight and lower scale for slow (2 m s^{-1}) flight. Redrawn from Muijres et al. (2011a). (B) Lift coefficients (C_L) reach values above maximum steady-state values at low speeds at mid-downstroke. Upstroke is shaded gray.

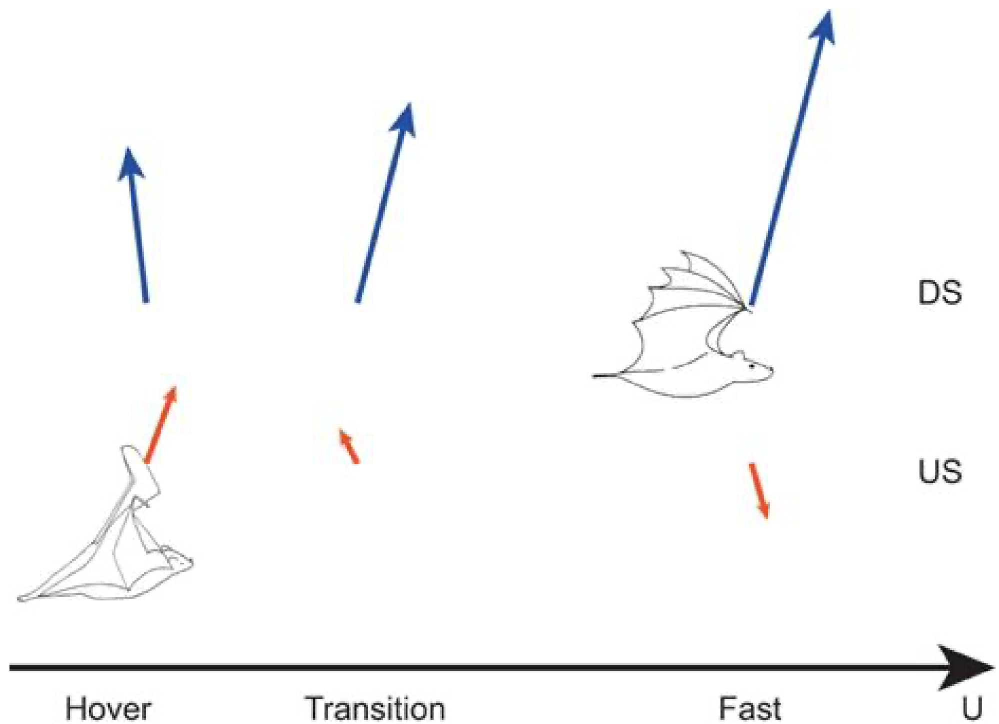


Figure 2: **Schematic illustration of forces generated by the downstroke (DS) and upstroke (US).** Forces developing at hover, the transition speed where forward speed and wing speed are similar but have opposite direction, and at fast cruising speed are shown. The arrows show relative magnitude and direction of the aerodynamic forces.

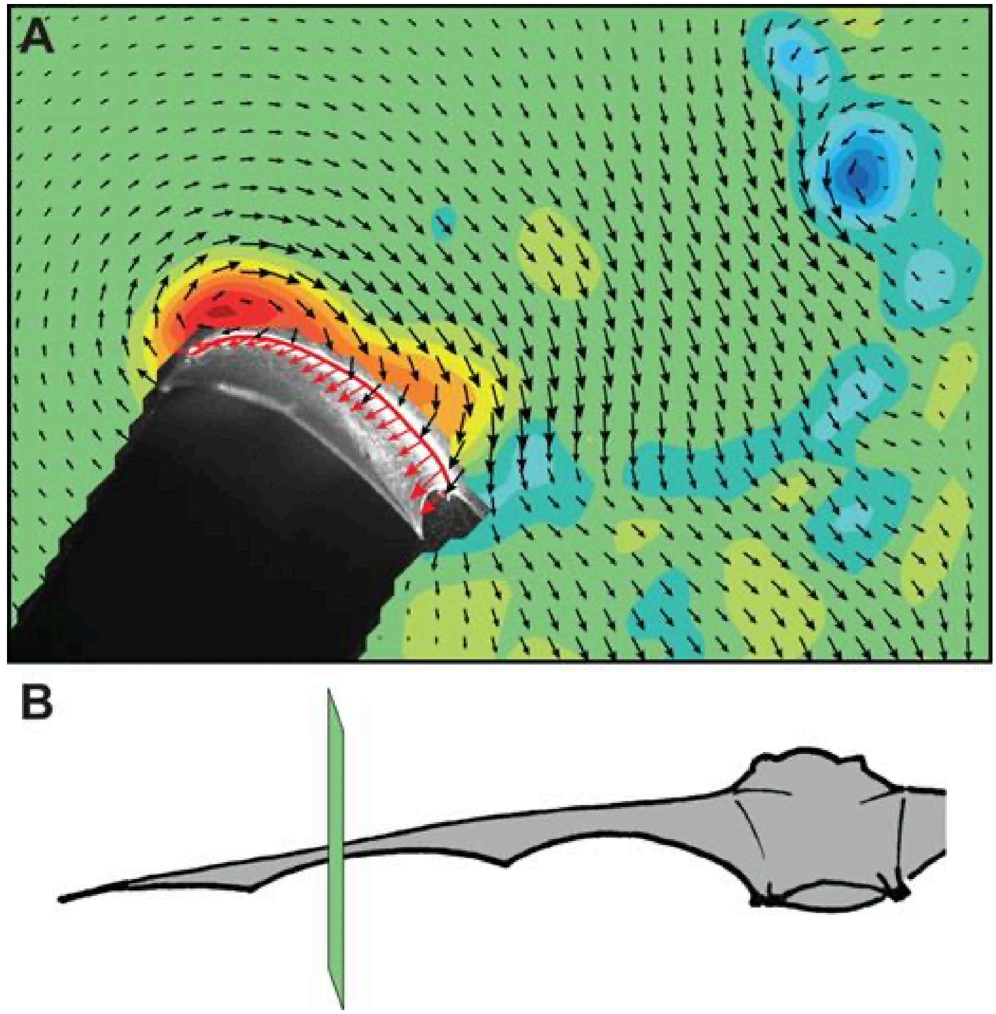


Figure 3: **A leading edge vortex attached to the wing midway through the downstroke of a Palla's long-tongued bat *Glossophaga soricina*.** (A) The blue patch in the top right corner is the start vortex shed at the beginning of the downstroke when lift is increasing rapidly. The black arrows show the induced velocity field, whereas red arrows along the wing chord show the velocity of a mid-wing segment. (B) Position along the wingspan of the measurement in A. Based on Muijres et al. (2008).

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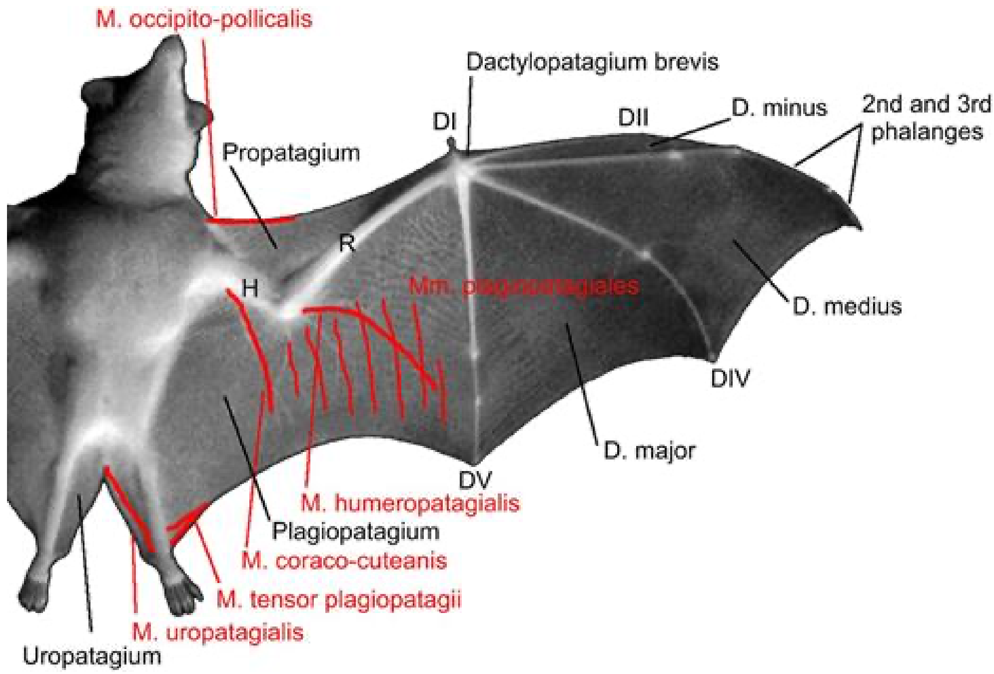
<tr><td></td><td>

Figure 4: Morphology of the bat wing. Humerus (H), radius (R), the digits (DI–DV) and the different membranes, propataguim, plagiopatagium, dactylopatagium (d. brevis, d. minus, d. medius, d. major), uropatagium and a number of muscles (red) associated with tensioning of the wing membrane are indicated.</td></tr>
<tr><td>VOCAB: (w/definition)</td><td>1. Kelvin's circulation theorem-that for change in aerodynamic force on a wing, such that will occur during the stroke of a bat, there will be a vorticity shed into the wake matching exactly the change in aerodynamic force.
2. Span efficiency - the ratio of the ideal induced power and measured induced power.
3. Uropatagium-the membrane between the legs of bats.
4. Wake vortices-function of an airfoil producing lift-. Wake Turbulence</td></tr>
<tr><td>Cited references to follow up on</td><td>Norberg, U. M. and Rayner, J. M. V. (1987). Ecological morphology and flight in bats (Mammalia; Chiroptera): Wing adaptations, flight performance, foraging strategy and echolocation. Philos. Trans. R. Soc. B 316, 335-427. https://doi.org/10.1098/rstb.1987.0030
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https://doi.org/10.1111/j.1469-7998.1996.tb05295.x
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Pelletier, A. and Mueller, T. J. (2000). Low Reynolds number aerodynamics of low-aspect-ratio, thin/flat/cambered-plate wings. J.</td></tr>
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	Aircr. 37, 825-832. https://doi.org/10.2514/2.2676 Google Scholar Pennycuick, C. J. (1971). Gliding flight of the dog-faced bat Rousettus aegyptiacus observed in a wind tunnel. *J. Exp. Biol.* 55, 833-845. Google Scholar Pennycuick, C. J. (1973). Wing profile shape in a fruit-bat gliding in a wind tunnel determined by photogrammetry. *Period. Biol.* 75, 77-82. Google Scholar Pennycuick, C. J. (1975). Mechanics of flight. In *Avian Biology* (ed. D. S. Farner and J. R. King), Vol. 5, pp. 1-75. New York, NY: Academic Press. Google Scholar
Follow up Questions	1. Are there aerodynamic features unique to bats? 2. Why is a high coefficient of lift also required when a bat takes a fast turn? 3. Are bats more efficient than birds at high wind speeds? 4. Are bats more efficient at producing lift when there is a crosswind moving in a direction that is different from the direction of their flight?

Article #20 Notes: Pterosaurs evolved a muscular wing-body junction providing multifaceted flight performance benefits: Advanced aerodynamic smoothing, sophisticated wing root control, and wing force generation

Source Title	Pterosaurs evolved a muscular wing-body junction providing multifaceted flight performance benefits: Advanced aerodynamic smoothing, sophisticated wing root control, and wing force generation
Source citation (APA Format)	Pittman, M., Barlow, L. A., Kaye, T. G., & Habib, M. B. (2021). Pterosaurs evolved a muscular wing–body junction providing multifaceted flight performance benefits: Advanced aerodynamic smoothing, sophisticated wing root control, and wing force generation. *Proceedings of the National Academy of Sciences*,

	118(44), e2107631118. https://doi.org/10.1073/pnas.2107631118
Original URL	[10.1073/pnas.2107631118](https://doi.org/10.1073/pnas.2107631118)
Source type	Journal Article
Keywords	Pterosaurs, fossil soft tissue, wing root fairing, aerodynamics, flight performance
#Tags	Fossil Soft Tissue
Summary of key points + notes (include methodology)	The first vertebrate to ever fly were pterosaurs. But, there are still knowledge gaps regarding different details of their flight anatomy and overall flight performance. Direct soft tissue was observed as direct evidence to support pterosaurs had wing root fairings with a laser stimulated fluorescence. It differed from bats and birds due to it being made mostly of muscle vs. fur or feathers. Pterosaurs likely used these farings to increase their flight capabilities by controlling their wing root fairings. This would aid in elevation and overall force generated during the flight stroke. More research is still required to fill in knowledge gaps. ● Laser-stimulated fluorescence is used to examine evidence of soft tissue of a wing root fairing from a pterosaur. ● First group of vertebrates to have powered flight ● Have membrane held by long fourth finger ● Only bats today use a sign with a membrane ● Power for flight comes from putting enough momentum in the surrounding air to beat the drag force. ● Wing root fairings are typically added between the aircraft fuselage and wing, and prominent in low wing configurations as it shows greater benefit. ● Birds use feathers that make a convex shape on the upper and lower surfaces that refine the chamber, and create a wing fairing. TThis allows the airflow to be smooth. ● They have identified these in the bones of pterosaurs but not the tissues. ● A 405-nm blue laser diode was shot from the line lens and scanned over the specimen, giving pictures. ● Soft tissues and bones appear pink with creamy colors. ● Propatagium and uropatagium are observed ● There is a lot of soft tissue around the neck, shoulders, and forewing. ● This provides direct evidence for there being a biological wing root fairing in a pterosaur, enabling the pterosaur to smooth airflow across the wings, and this is made of soft tissue between the cranial

	end of the sixth cervical vertebrae and the proximal end of the humerus. ● This contrasts with previous interpretations. ● This image is viewed as soft tissue making the fairing, mainly being made of skeletal muscle. ● Musculature seems to be integrated with the propatgatial membrane, meaning these muscles probably went through the membrane of the wing. ● It is proposed this was enough to maintain tension while the pterosaur was soaring, during higher speeds and flight strokes the wing wouldn't be at full span. ● Pterosaurs may have even more extensive use of these muscles. ● However, it was preserved only in 2D, and there isn't evidence directly supporting a camber. ● The fairing might have helped with wing elevation, wing motion during the flight stroke to overall generate more force. ● Fairing is similar to bats and birds, and fairing muscle aided pterosaurs in mobile insectivore ecology.
Research Question/Problem/ Need	Did pterosaurs have fairings, and if so how did they affect the flight of pterosaurs?

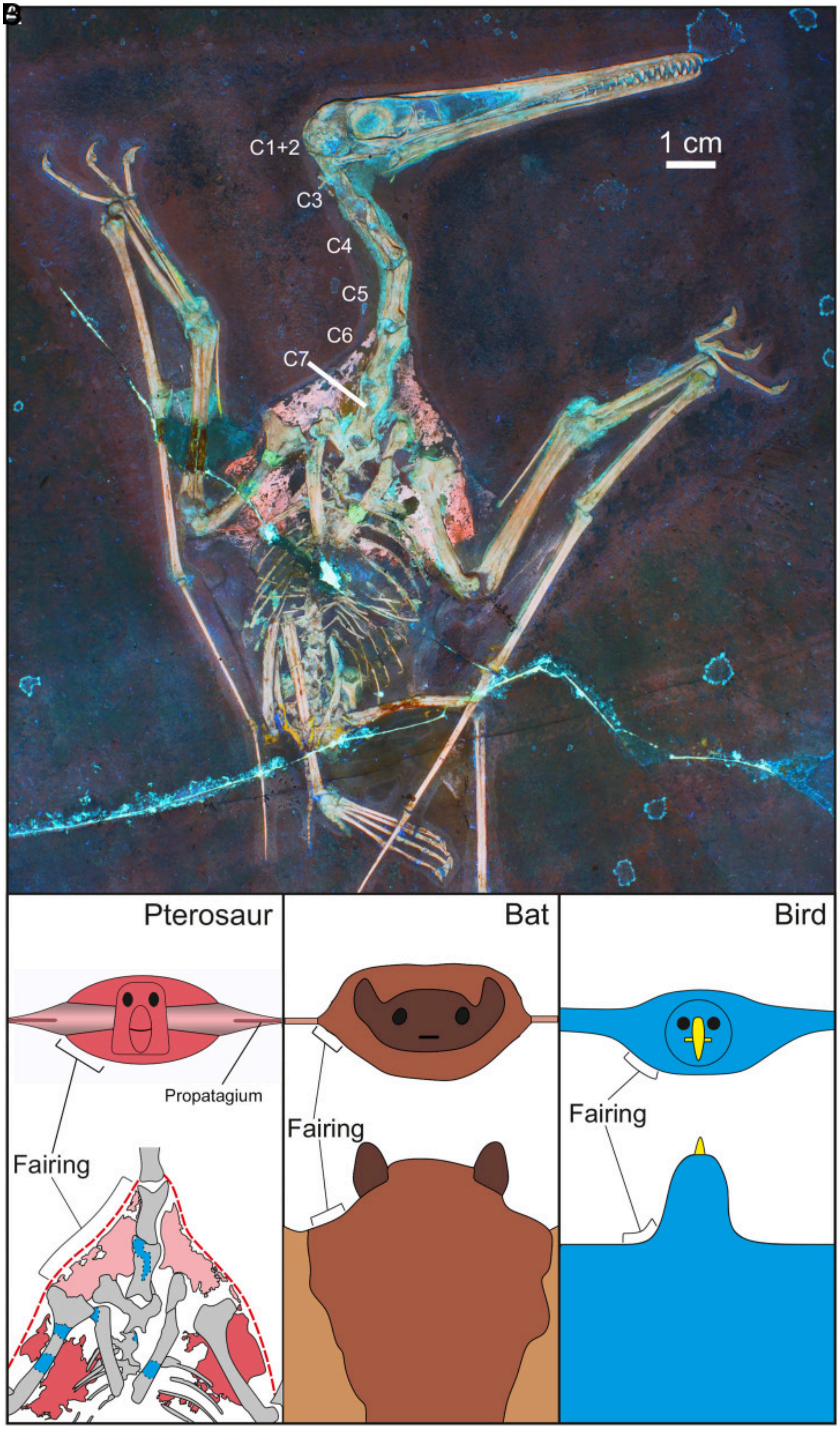
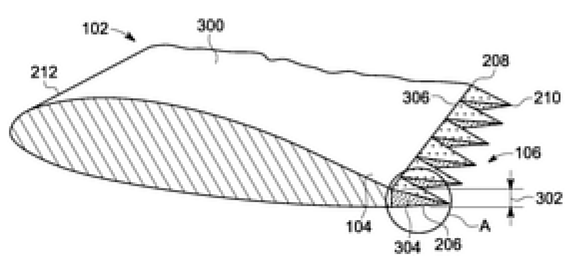
Important Figures	

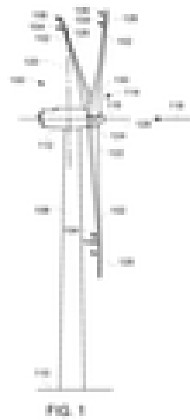
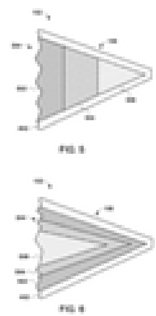
	Figure 1: Pterodactyloid pterosaur BSP 1937 I 18 reveals soft tissues around the base of the neck, the shoulders, and the upper arm. BSP 1937 I 18 was recovered from the Late Jurassic Solnhofen Limestones of Southern Germany. (*A*) Observed soft tissues around the base of the neck, the shoulder, and the forewing (brachium). (*B*) Conceptual drawing of the wing root fairing (light pink) in life in anterior view as well as its two-dimensional preservation in the fossil. (*C*) Bats have a fur-dominated wing root fairing (anterior and dorsal view). (*D*) Birds have a feather-dominated wing root fairing (anterior and dorsal view).
VOCAB: (w/definition)	1. Fluorescence - the visible or invisible radiation emitted by substances as a result of a shorter wavelength such as x-ray. -Oxford Languages 2. Fairings- smooth shapes and joints on the aircraft, including the wing root, wing tips, and the landing gear. Fairings are typically curved sections and are used to direct airflow smoothly over the structure, which reduces profile drag and (in some cases) helps prevent stall by delaying flow separation. 3. Patagia-a membrane or fold of skin between the forelimbs and hind limbs on each side of a gliding animal. - Oxford Languages 4. Taphonomic-a branch of paleontology that deals with the processes of fossilization. -Oxford Languages
Cited references to follow up on	1. Witton M. P., *Pterosaurs: Natural History, Evolution, Anatomy* (Princeton University Press, Princeton, 2013). [Google Scholar] 2. Jacobs E., Ward K., *Interference of Wing and Fuselage From Tests of 209 Combinations in the N.A.C.A. Variable-Density Test Tunnel. Langley Field* (National Advisory Committee for Aeronautics, 1935). [Google Scholar] 3. Anscombe A., Raney D. J., *Low-Speed Tunnel Investigation of the Effect of the Body on Cm₀and Aerodynamic Centre of Unswept Wing-Body Combinations* (Aeronautical Research Council Current Papers, 1950), p. 16. [Google Scholar] 4. Maughmer M., Hallmann D., Ruszkowski R., Chappel G., Waitz I., Experimental investigations of wing-fuselage integration geometries. *AiAA J. Aircraft.* (8):705–711 (1989). [Google Scholar] 5. Homberger D. G., de Silva K. N., Functional microanatomy of the feather-bearing integument: Implications for the evolution of birds and avian flight. *Am. Zool.* **40**, 553–574 (2000). [Google Scholar] 6. Savile D. B. O., Adaptive evolution in the avian wing. *Evolution* **11**,

	212–224 (1957). [Google Scholar] 7. Brown R. E., Baumel J. J., Klemm R. D., Anatomy of the propatagium: The great horned owl (*Bubo virginianus*). *J. Morphol.* **219**, 205–224 (1994). [PubMed] [Google Scholar] 8. Habib M., Whitlatch T., *Flying Monsters: Illustrating Flying Vertebrates Real and Imagined*(Design Studio Press, Los Angeles, 2021). [Google Scholar] 9. Palmer C., Flight in slow motion: Aerodynamics of the pterosaur wing. *Proc. Biol. Sci.* **278**, 1881–1885 (2011). [PMC free article] [PubMed] [Google Scholar]
Follow up Questions	1. What specific functions did the pterosaur fairings serve for the pterosaur? 2. How does the pterosaur fairing differ from bat and bird fairings because it is made of muscle? 3. Why doesn't the 2D wing root fairing show evidence of the chamber, unlike early birds such as the Anchiornis? 4. How specialized was the muscle-membrane interaction in pterosaurs, and what did this enable them to do?

Patent #1 Notes: Methods and apparatus for producing wind energy with reduced wind turbine noise

Source Title	Methods and apparatus for producing wind energy with reduced wind turbine noise
Source citation (APA Format)	Drack, Lorenz Edwin, et al. *Wind Turbine Noise Reduction with Acoustically Absorbent Serrations*. US11268489B2, 8 Mar. 2022, https://patents.google.com/patent/US11268489B2/en?q=(wind+turbine+noise)&oq=wind+turbine+noise.

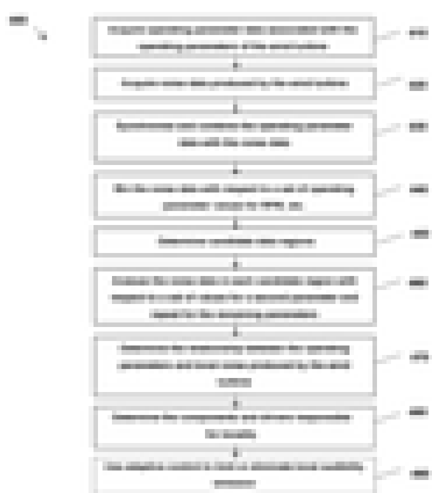
Original URL	https://patents.google.com/patent/US11268489B2/en?q=(wind+turbine+noise)&oq=wind+turbine+noise
Source type	Patent
Keywords	Trailing edge, wind turbine
#Tags	Trailing edge
Summary of key points + notes (include methodology)	In this patent, a wind turbine blade has a radially inboard section of the trailing edge, as well as the radially outboard section. A structure is included to allow the attachment of the trailing edge to a serrated section. This serrated section has material that absorbs sound. Finally, there is a method to reduce the noise production from wind turbine blades using a trailing edge and corresponding system. ● Revolves around reducing the acoustics from wind turbine blades specifically ● Wind farms use lift and the normal force to rotate, creating electricity. ● There are aerodynamic acoustic emissions from the blades ● Wind turbine blade, includes trailing edge that is the inboard positions nd one that is the outboard position, ● The added system includes a mount, and a serrated section ● Serrated section-base and different tip portion, and serrated edge ● Serrated edge spans from the base to tips away from the trailing edge. ● The serrated section includes a material that is sound absorbent ● The magnitude of sound reflected from the blade is reduced by the sound absorbent material ● As blade tip speed increases, the amplitude of noise emission increases
Research Question/Problem/ Need	How to reduce the noise given off by wind turbine blades.
Important Figures	 Figure 1: Depicts a section of the trailing edge. There are serrations to stabilize the windstreams going by. It displays the use of sound absorbent

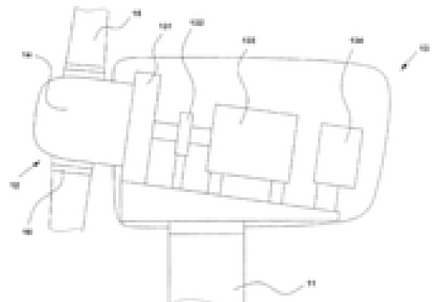
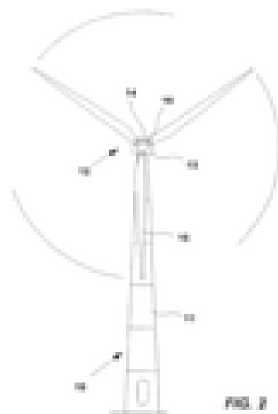
	material to further this goal.  Figure 2: An overall depiction of the wind turbine with the integrated/updated blades. These blades include trailing edge serrations and a sound absorbent material.  Figure 3: A depiction of the insides of the sound absorbent material. This exemplifies the integration of more than one level of sound absorbent material to maximize the reduction of sound given off by the blade.
VOCAB: (w/definition)	1. Radially-in a way that spreads from the central point. -Cambridge Dictionary 2. Serration-resembles a tooth or wave, comparable to the deg of a saw. -Oxford Languages 3. Epoxy - a class of adhesives, plastics. -Oxford Languages 4. Torque- a twisting force that tends to cause rotation. -Oxford Languages
Cited references to follow up on	9,719,490 B2 8/201 Caruso et al. 9,841,002 B2 12/2017 Oerlemans 2003/0175121 A1 9/2003 Shibata et al. 2008/0107540 A1 5/2008 Bonnet 2009/0290982 A1 11/2009 Madsen et al.

Follow up Questions	1. What is the sound absorbent material used? 2. What specifically about the sound absorbent material makes it sound absorbent? 3. How is the airstream steadied by the serrations? 4. How did the integration of the different sections of each blade work?

Patent # 2 Notes: Wind turbine noise analysis and control

Source Title	Wind turbine noise analysis and control
Source citation (APA Format)	GUPTA, Mranal, and Niels Christian M. Nielsen. *Wind Turbine Noise Analysis and Control*. US11255310B2, 22 Feb. 2022, https://patents.google.com/patent/US11255310B2/en?q=(wind+turbine+noise)&oq=wind+turbine+noise.
Original URL	https://patents.google.com/patent/US11255310B2/en?q=(wind+turbine+noise)&oq=wind+turbine+noise
Source type	Patent
Keywords	Wind turbine, noise
#Tags	Wind turbine
Summary of key points + notes (include methodology)	This patent developed a method of identifying tonal noise, and where the tonal noise originated. The aspect that generates the tonal noise is defined as parameters. This method entails identifying multiple parameters linked with data. Noise measurements are acquired through the use of microphones, including any tonal noise there may be. Then, the data is categorized into different bins, and is examined by comparing it to values from another parameter. Then ,it identifies whether or not there is a correlation between that operating parameter and tonal noise generation.

	● The noise created by wind turbines is a known issue. ● The noise entails mechanical and aerodynamic noise. ● Mechanical noise is created from the parts in the nacelle, including the drivetrain. ● This noise can be radiated from the vibrating surface itself, or through the wind turbine itself. ● Aerodynamic noise from the blades includes vortex-shedding. ● Both broadband specific individual frequencies are generated by wind turbines. ● Tonal noise is more harmful but had to predict ● The methods for looking at tonal noise aren't sufficient currently. ● Microphones are used to measure noise, RPM is taken and can be related to both sound and power generation. ● EIC associates wide ranges of frequency as tone of the same origin which isn't accurate. ● Tonal noise analysis is therefore conducted by setting the parameters of wind turbines to avoid values that yield tonal noise. ● Method wants to identify an operating parameter, and component that makes tonal noise. Then, it wants to obtain and categorize noise data based on a parameter ● This aids in identifying the origin of tonal noise ●
Research Question/Problem/ Need	Wind turbines generate noise that is harmful, specifically tonal noise and often tonal noise is generalized to be inaccurate.
Important Figures	 FIG. 4 Figure 1: Outlines the steps employed by the described method.

	 Figure 2: A simplified version of the nacelle section of a wind turbine.  FIG. 2 Figure 3: Standard diagram of the average modern wind turbine.
VOCAB: (w/definition)	1. Pitch-the angle of attack of the blades with respect to the wind. 2. Pitch variation-the variation in pitch measured during a time period. 3. Power/torque variation-the variation in the power/torque measured during a period of the wind turbine operation. 4. Yaw angle-the angle of rotation of the nacelle around its vertical axis. 5. Tonal energy-energy contained in a tone
Cited references to follow up on	Publication number Priority date Publication date Assignee Title WO2003064853A1 * 2002-01-29 2003-08-07 Abb Ab Apparatus and method for operation of a power generating plant US20040151578A1 * 2001-03-28 2004-08-05

	Aloys Wobben Method for monitoring a wind energy plant US6785637B1 * 1999-10-06 2004-08-31 Aloys Wobben Method for monitoring wind power plants US20070031237A1 * 2005-07-29 2007-02-08 General Electric Company Method and apparatus for producing wind energy with reduced wind turbine noise US7239738B2 * 2002-09-13 2007-07-03 Fuji Xerox Co., Ltd. Image defect inspecting apparatus and image defect inspecting method US20080164091A1 2007-01-05 2008-07-10 Lutz Kerber Tonal emission control for wind turbines US20090039650A1 * 2007-08-10 2009-02-12 Jacob Nies Event monitoring via combination of signals US20100133818A1 2009-07-07 2010-06-03 General Electric Company Method and system for noise controlled operation of a wind turbine US7883317B2 * 2007-02-02 2011-02-08 General Electric Company Method for optimizing the operation of a wind turbine US20110084485A1 * 2009-10-08 2011-04-14 Vestas Wind Systems A/S Control method for a wind turbine US20110135442A1 * 2009-12-09 2011-06-09 Lutz Kerber System, device, and method for acoustic and visual monitoring of a wind turbine US20120061957A1 * 2009-12-17 2012-03-15 Guillaume Steinmetz Method for operating a wind turbine in a power-reduced mode of operation EP2461025A2 *

	2010-12-06 2012-06-06 General Electric Company System, device, and method for noise-based operation of wind turbines JP2014506971A * 2011-02-08 2014-03-20 ヴォッベン プロパティーズ ゲーエムベーハー How to determine lost energy CN103797244A 2011-08-16 2014-05-14 维斯塔斯风力系统集团公司 Acoustic noise monitoring system for a wind turbine US20140327243A1 2011-12-30 2014-11-06 Vestas Wnd Systems A/S Wind turbine generator with adaptive locked speed operation US20140377065A1 * 2011-12-26 2014-12-25 Vestas Wind Systems A/S Method for controlling a wind turbine CN105337283A 2015-12-11 2016-02-17 北京天诚同创电气有限公司 Method, device, controller and system for reducing vibration and noise of motor WO2017198270A1 2016-05-18 2017-11-23 Vestas Wind Systems A/S Analysis of wind turbine noise WO2018086671A1 2016-11-14 2018-05-17 Vestas Wind Systems A/S Wind turbine noise analysis and control US20200182224A1 * 2016-09-07 2020-06-11 Vestas Wind Systems A/S Predicting wind turbine noise US20210048006A1 * 2019-08-16 2021-02-18 Rws, Llc Multi-substrate noise mitigation system for monopole towers of wind turbine systems US11022092B2 * 2015-12-22 2021-06-01

	Vestas Wind Systems A/S Method and a system for mounting a rotor to a drive shaft of a wind turbine US11105316B2 * 2016-12-23 2021-08-31 Vestas Wind Systems A/S Wind turbine temperature dependent noise reduction Family To Family Citations
Follow up Questions	1. How is the interaction between two different parameters distinguished? 2. How would taking into account the velocity of the wind possibly affect tonal noise? 3. How does the interaction of the tonal noise and aerodynamic noise affect people? 4. How will the tonal noise be mitigated after where it is coming from has been identified?

Patent # 3 Notes:Low-noise tip airfoil geometry for urban small wind turbines in low wind speed condition

Source Title	Low-noise tip airfoil geometry for urban small wind turbines in low wind speed condition
Source citation (APA Format)	Lee Soo-gap, et al. Tip airfoil of wind turbine blades for urban low wind speed/constant speed operation with reduced noise level. KR20110092609A, 18 Aug. 2011, https://patents.google.com/patent/KR20110092609A/en?q=(airfoil+noise)&oq=airfoil+noise.
Original URL	https://patents.google.com/patent/KR20110092609A/en?q=(airfoil+noise)&oq=airfoil+noise
Source type	Patent
Keywords	Low-noise, airfoil, wind turbine
#Tags	Low-noise
Summary of key points +	The patent observes the tip airfoil of a wind turbine blade for a low, constant

notes (include methodology)	speed. Noise levels are reduced, and the lift-drag ratio is increased to mitigate the overall sound pressure levels given off by an airfoil. The tip airfoil Reynolds number is 1,000,000 for its given wind speed that happens to be low. This airfoil tip includes the front side, trailing side, pressure sides, and suction side. There is a space between the front and trailing sides. This is where the pressure side is located, as well as the suction side. ● Shape of the tip of an airfoil is correlated to cross-sectional airfoils of a wind turbine blade. ● Generally, wind power generators convert kinetic energy from the wind to electricity via the rotation of blades. ● Wind turbines are being installed not only on land but also in the sea , being offshore wind turbines. ● Noise from these wind turbines has effects on residencies and ecosystems. ● Onshore wind turbines-mechanical noise and aerodynamic noise. ● Mechanical noise typically reduced through shielding ● Reducing revolutions per minute reduces sound, but also reduces power. ● The shape of an airfoil determines the range for the Reynolds numbers ● Ratio of lift is typically used for airfoils ● Typically aircraft airfoils have ratio of <40, but blades have upwards of 80 ● Angle of attack, chord thank, max thickness, and the angle formed by the wind blowing centerline on the wing are factors that influence wind turbine blades. ● Goal is to give an airfoil shape with specialized characteristics for the tip portion of a 10kW class small wind turbine to improve performance and efficiency. ● Goal is to also reduce sound pressure level of the airfoil ● Tip of blade includes front face, rear face (with space in between), suction and pressure face. ● Suited for a wind speed of 10 m/s ● Max lift coefficient of 1.0-1.2 ● Thickness ratio should be high ● Thickness of the tip airfoil was set to 17%-10% ● There is tip noise, turbulent boundary layer trailing edge noise, laminar boundary layer vortex shedding noise, inflow turbulence noise, blunt trailing edge noise ● Noise in eternal is created form the blades interaction with the wind
Research Question/Problem/ Need	How can the noise of an airfoil for an aerogenerator blade for urban type low wind speeds be reduced?

Important Figures

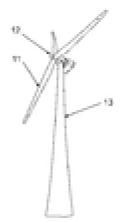


Figure 1: First, as shown in FIG. 1, a typical wind power generator includes rotors 11 and 12 that perform a continuous process of extracting kinetic energy from wind and converting it into useful mechanical power, but not shown, blade pitch control and stalling. Power control system for avoiding too high drive power and torque at high wind speed through control, drive device and load transmission part for transmitting power and converting power to rotor shaft rotating at high speed to drive generator, although not shown Although not shown, the electric system converts mechanical energy into electrical energy, and the tower 13 supports the nacelle and transmits the entire load to the support of the ground.

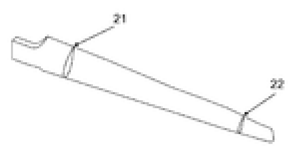


Figure 2:In addition, the entire length R of the blade excludes a portion for connecting with the rotor hub, and as shown in FIG. 2, the cross section is sharply reduced at the blade end to exclude a portion where a step is formed. In the present invention, the total length of the blade is 3 ~ 3.5m in consideration of the wind speed, the tip airfoil is designed to suit this.

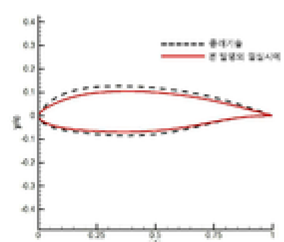


Figure 3: Figure 3 illustrates a superimposed profile of the tip airfoil according to the present invention and the tip airfoil according to the prior art.

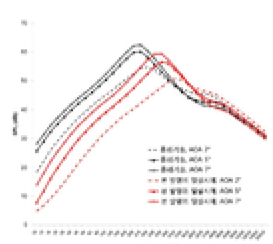


	Figure 4: Figure 4 is a graph of the noise level for each frequency according to the change in the angle of attack of the tip a-foil of the preferred embodiment according to the present invention.
VOCAB: (w/definition)	1. turbulent boundary layer - boundary layer flow contains eddies and curls.-Turbulent Boundary Layer - an overview | ScienceDirect Topics 2. laminar boundary layer- boundary layer flow is steady. -Turbulent Boundary Layer - an overview | ScienceDirect Topics 3. Vortex shedding - when the wind blows across a structural member, vortices are shed from one side to anotherVortex Shedding - an overview 4. Inflow Turbulence noise -caused by the flow- surface interaction, when the atmospheric turbulence encounters the rotor blades.-DISCUSSION ON TURBULENT INFLOW NOISE PREDICTION
Cited references to follow up on	No Cited References
Follow up Questions	1. How does the thickness of the section leading to the tip influence aerodynamic noise? 2. Which section of the airfoil generates the most noise? 3. How is the noise specifically mitigated by this new blade design? 4. How would scaling this smaller blade affect the sound produced for larger wind turbines?