International Assessment of Priority Environmental Issues for Land-Based and Offshore Wind Energy Development

WREN Webinar #19

June 29th, 2022

Implementing Agreement for Co-operation in the Research, Development, and Deployment of Wind Energy Systems

WREN Priority Assessment

- **Agenda**
  - **Welcome & WREN Introduction**
  - **Assessment Introduction and Methods**
  - **Land-based wind**
    - **Results**
    - **Panel discussion**
  - **Offshore wind**
    - **Results**
    - **Panel discussion**
  - **Key Outcomes**
  - **Next Steps**
  - **Questions from Audience**

WREN Introduction

- International Energy Agency Wind Technology Collaboration Program
  - Task 34: Working Together to Resolve Environmental Effects of Wind Energy
  - Initiated in Oct 2012; Currently in its 3rd phase (Oct 2020–Sept 2024)
  - 13 Member countries

- An international forum for supporting deployment of wind energy through a better understanding of environmental issues, particularly those related to efficient monitoring programs and mitigation strategies.

- Identify priority international needs for further research
  - Focus of today's webinar
- Aggregate and disseminate information on the global state of the science
  - Webinars, short science summaries, reports, and publications
  - Tethys website (https://tethys.pnnl.gov)
- Develop & maintain a monitoring and minimization technologies tool
  - Soon to be released web-based list of technologies and the associated literature

Special Thanks to Karin Sinclair

- NREL's environmental portfolio lead for ~25 yrs
- Managed WREN from 2012–2018
  - Initiated Task 34
  - Successful proposal for Phase 2
- Valued mentor 2018–2022
- Sinclair et al. 2018. Resolving environmental effects of wind energy. *WIREs Energy & Environment*
- Contributed to
  - 4 other publications/technical reports
  - 19 webinars
  - 11 science summaries/fact sheets

WREN Priority Assessment

- **Vision:** Inform WREN state of the science activities by conducting a systematic (i.e., repeatable, inclusive, & transparent) assessment using feedback from the global wind energy & environmental community to identify priority future environmental issues for wind energy development.

- **Scope**
  - Land-based wind (LBW) & Offshore wind (OSW)
  - Wildlife and Environmental Sciences
  - International (Africa, Asia Pacific, Central & South America, Eurasia, Europe, Middle East, North America)
  - Stakeholder groups (e.g., Gov, NGOs, Industry, Academic, Financing, etc.)

- **Target**
  - Priorities for LBW stressors & receptors
  - Priorities for OSW stressors & receptors
  - Primary challenges to implementing proven monitoring or mitigation approaches
  - Topics to inform WREN Years 2–4 State of the Science activities

WREN Priority Assessment

Project Team

- **Overall:** NREL is leading the overall effort and is guided by a Steering Committee with additional membership from WREN and DOE.

- **Coordinators**
  - NREL: Rebecca Green, Liz Gill, and Cris Hein

- **Steering Committee Members**
  - DOE: Naomi Lewandowski, Jocelyn Brown-Saracino, and Joy Page
  - WREN members
    - Lydie Couturier, France
    - Miguel Mascarenhas, Portugal
    - Roel May, Norway
    - David Newell, Sweden
    - Bob Rumes, Belgium

- **Participants**
  - World-wide wind and environmental experts providing feedback.

Credit: FWS

WREN Priority Assessment

Methods

- **Horizon Scanning** – A process which allows for systematically investigating evidence about future trends, including research priorities & emerging issues in science and policy.

- **Modified Approach** – Included persistent & emerging issues.

- **Framework** - Organizers identify the objectives, solicited feedback, & collated issues from a large, diverse group of individuals.

    - Decision Delphi technique

        - Scan & identify issues

        - Consolidate & cluster issues

        - Reduce set of suggestions through iterative voting process

        - Produce a final list of topics

Credit: NOAA

Figure 1. Horizon Scan Flow of Study

- Conducted during January – December 2021
    - Questionnaire 1: March – June
    - Questionnaire 2: August – October
- Developed questionnaires with team
- Broadly disseminated questionnaires
    - Using Google Forms
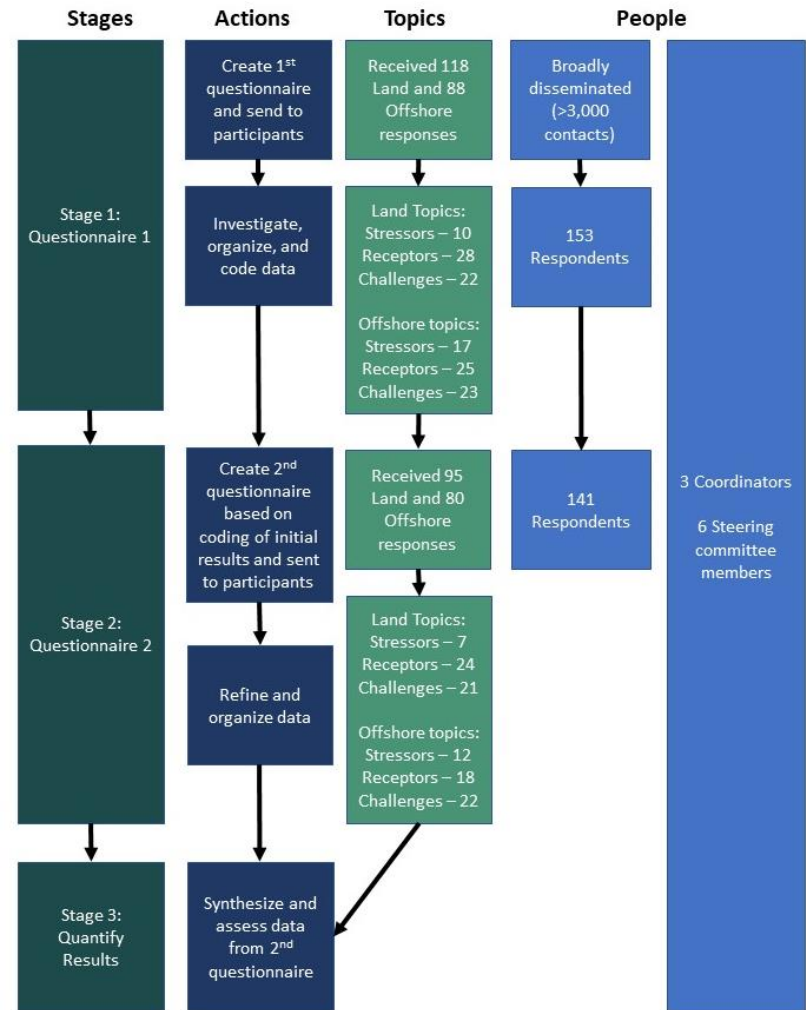- 294 total respondents
- 28 countries represented

Table 1. First Questionnaire

Category	Question
General	Professional sector
	What is your experience with environmental effects associated with wind energy? (length of time)
	What environmental context does your work cover? (Land-based, offshore, or both)
	Environmental area of experience or focus (Choose all that apply)
	Country where you have the most expertise and which your responses represent.
	What is the current installed capacity of wind energy (land-based and offshore) in your country?
	What is the expected growth of wind energy development in the next 10 years in your country?
Environmental	What do you anticipate being the 1st priority environmental issue related to wind energy development in your country in the next 5–10 years?
	If applicable, what is the specific stressor-receptor relationship associated with this issue?
	What level of impact to the receptor do you anticipate for this issue? E.g., individual, population, etc.
	What scale of impact do you anticipate for this issue? E.g, local, regional, biogeographical, or global.
	What are the next steps to improving how we monitor this issue?
	What are the next steps to validating and implementing cost-effective mitigation strategies (avoid, reduce, minimize, compensate, restore) associated with this issue?
Additional Considerations	What are the primary considerations, such as societal, financial, political, regulatory, environmental, or other, to implementing proven monitoring or mitigation approaches associated with this issue?

Table 2. Second Questionnaire

Category	Question
General	Professional Sector (Select the sector where you have the most experience)
	Environmental area of expertise (Choose all that apply)
	Country where you have the most expertise and which your responses represent.
Environmental	Please identify your top priority stressor for LBW/OSW.
	Please identify your top priority receptor.
	Please identify your second priority stressor for LBW/OSW. (optional)
	Please identify the associated receptor (optional)
	Please identify your third priority stressor for LBW/OSW. (optional)
	Please identify the associated receptor (optional)
	Is there a truly "emerging" environmental issue (vs. persistent issue) that hasn't previously been identified?
Additional Considerations	For LBW/OSW, in general what are the primary challenges associated with implementing proven monitoring or mitigation approaches? (Choose up to 3)
	Is there any additional feedback that you'd like to provide to inform this Horizon Scan? (Optional)

Table 3. Responses by Country

- First questionnaire received 153 responses across 23 different countries.

  – Most respondents from Europe (55%) & North American (31%)

  – Also received responses from Africa, Asia Pacific, Central & South America, & Eurasia.

- Second questionnaire received 141 responses from across 23 different countries.

  – Most responses from Europe (60%) & North America (30%)

  – Few responses from Africa, Asia Pacific, Central & South America, & Eurasia.

Region	Country	Q1	Q2
North America	United States	44	39
	Canada	3	2
	Mexico	1	1
Europe	Portugal	25	20
	Germany	12	9
	United Kingdom	11	9
	France	10	19
	Netherlands	9	7
	Belgium	5	4
	Norway	5	4
	Croatia	2	0
	Sweden	2	3
	Austria	1	0
	Switzerland	1	4
	Spain	1	2
	Lithuania	0	1
	Bulgaria	0	1
	Italy	0	1
Eurasia	Uzbekistan	0	1
	Jordan	1	0
	Israel	0	1
Asia Pacific	Japan	5	1
	Australia	2	4
	Vietnam	1	0
Central and South America	Brazil	8	4
	Argentina	1	0
Africa	South Africa	2	3
	Kenya	1	1

Figure 2. LBW Environmental Considerations from Q1

- First questionnaire = 118 responses
  - Stressors (n = 8)
  - Receptors (n = 24)

- Stressors included turbine collision, cumulative effects, & several behavioral interactions (e.g., avoidance & attraction)

- Receptors included birds, bats, fish, terrestrial animals, & habitat

- A range of monitoring & mitigation strategies were identified

- Primary challenges were grouped into 4 main categories

Stressors
- Attraction
- Avoidance
- Barrier effect
- Cumulative effects
- Decommissioning / Repowering
- Displacement
- Disturbance
- Turbine collision

Receptors
- **Amphibians**
- **Animal populations**
- **Bats:** In general; Cave-hibernating bats; Tree-roosting bats
- **Birds:** In general; Eagles; Raptors; Grassland nesting birds; Grouse; Migratory songbirds; Soaring birds (includes storks, vultures, condors, cranes)
- **Ecosystem level**
- **Fish:** Freshwater; Diadromous
- **Habitat:** In general; Connectivity; Forests; Freshwater; Protected areas
- **Reptiles**
- **Terrestrial mammals:** In general; Carnivores; Terrestrial mammals - Migrating land mammals (includes reindeer, elk, etc.)

Monitoring Needs
- Advanced radar, camera, and video systems for bird monitoring
- Line transects using Before-After Control-Impact studies
- Longer-term studies, including with tagged grouse
- Improved tracking for individuals
- Improved and automated detection systems, including to track eagles and other raptors
- Population monitoring and behavioral information for at-risk raptors
- Regional population studies
- Integrated monitoring approaches
- Miniaturizing GPS tags to track bat movements

Mitigation Strategies
- Compensate for loss of bats
- Buffer width guidelines for landscape features
- Mapping sensitive areas and corridors for genetic movement/migration
- Smart curtailment based on risk of collision
- Environmentally-friendly wind farm siting and turbine micro-siting tools
- Restoration of habitat within/surrounding wind farms
- Avoid based on detection
- Best management practices
- Monitoring
- Prohibit development in undisturbed areas

Primary Challenges
- **Environmental science:** In general; Mitigation effectiveness; Lack of consensus on monitoring; Lack of understanding of impacts; Regional coordination of research; Dissemination of science
- **Financial:** In general; Spending priorities; Costs for monitoring, minimization, and mitigation; Funds for regional-scale analyses
- **Regulatory:** In general; Government support for fees that cover costs; Enact guidelines/best practices; Environmental values; Environmental licensing process; Lack of oversight and enforcement; Stricter regulations; Bat/bird protections
- **Societal:** In general; Social acceptance of wind development; Public support lacking for species impacted; Workforce training

Figure 3. LBW Q2 Priorities

- Stressors
  - Turbine collisions (42%)
  - Cumulative effects (26%)
  - Avoidance (7%); Displacement (7%)
- Birds
  - "Birds in general" (35%)
  - Raptors and Eagles (35%)
  - Soaring (14%); Grassland nesting (7%); Migratory songbirds (6%); Grouse (3%)
- Bats
  - "Bats in general" (77%)
  - Tree roosting (22%)
  - Cave hibernating (1%)
- Ecosystems & Habitat
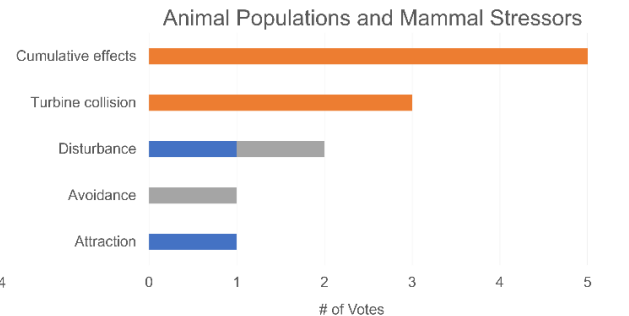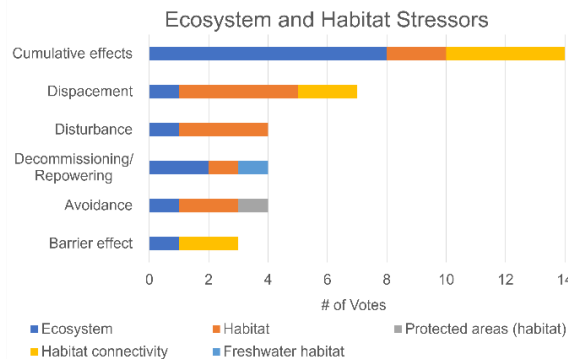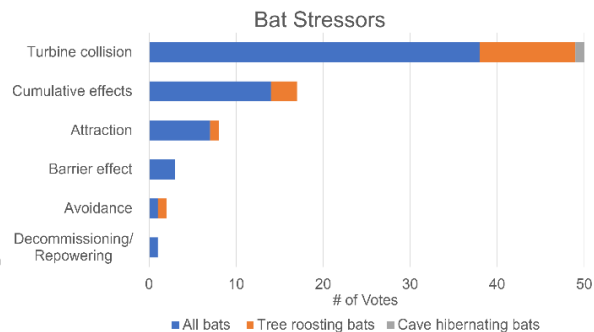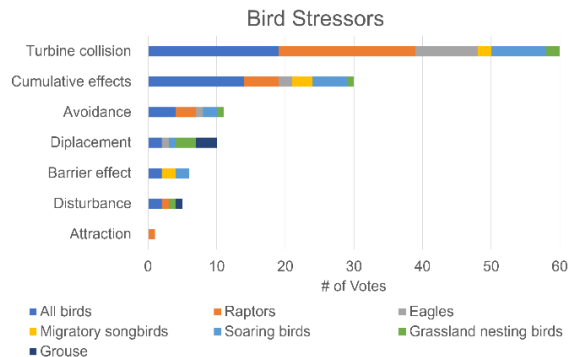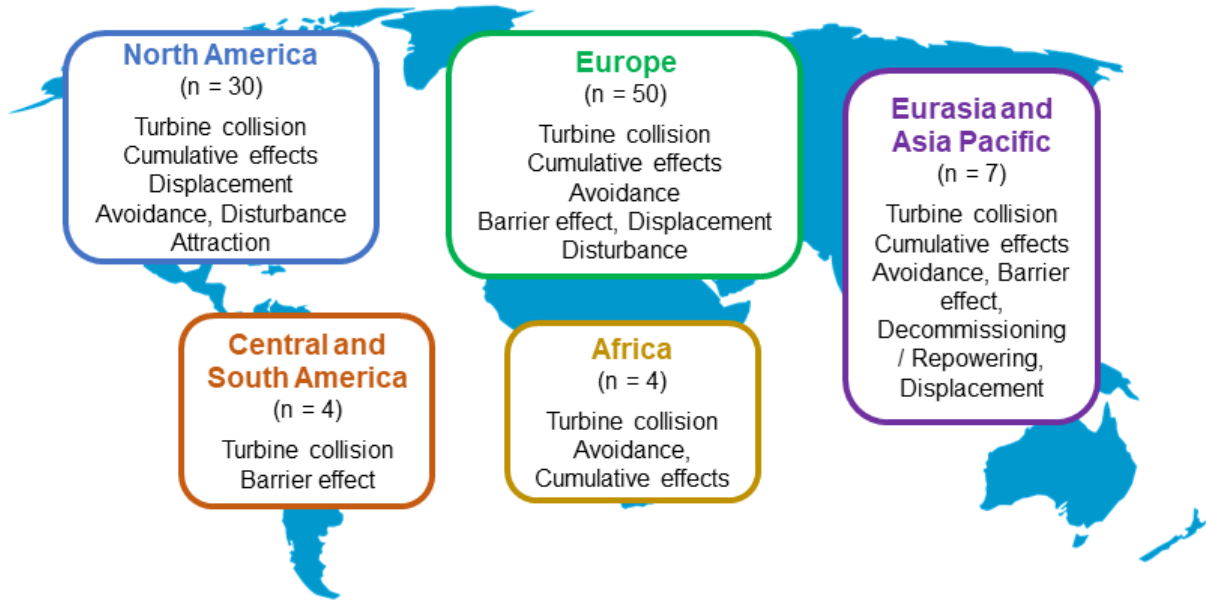- Animal Populations & Mammals

Figure 4. LBW Stressors by Region

- Turbine collision highest ranked stressor across regions

- Europe
  - Turbine collisions (48%)
  - Cumulative effects (24%)
  - Avoidance (10%)
  - Barrier effect, Displacement, Disturbance (each 6%)

- North America
  - Turbine collisions (39%)
  - Cumulative effects (27%)
  - Displacement (18%)
  - Avoidance, Disturbance (each 6%)

North America
(n = 30)
Turbine collision
Cumulative effects
Displacement
Avoidance, Disturbance
Attraction

Europe
(n = 50)
Turbine collision
Cumulative effects
Avoidance
Barrier effect, Displacement
Disturbance

Eurasia and Asia Pacific
(n = 7)
Turbine collision
Cumulative effects
Avoidance, Barrier effect,
Decommissioning / Repowering,
Displacement

Central and South America
(n = 4)
Turbine collision
Barrier effect

Africa
(n = 4)
Turbine collision
Avoidance,
Cumulative effects

Open Discussion: Panel and Participant on Land-Based Wind Environmental Issues

- **Panelists:**
  - Miguel Mascarenhas (Environmental Specialist; Project Manager, Bioinsight)
  - Roel May (Senior Research Scientist Norwegian Institute for Nature Research)
- **Questions:**
  - Based on your experience, for your country, which of these environmental issues are a priority?
  - What do you perceive as the challenges to implementing monitoring and mitigation strategies?
  - What are the opportunities for moving forward and resolving these issues?
  - What geographic differences between North America and Europe would you like to highlight?

Figure 5. OSW Environmental Considerations from Q1

- First questionnaire = 88 responses
  - Stressors (n = 13)
  - Receptors (n = 22)

- Stressors similar to LBW, but also included mooring lines & entanglement (e.g., floating wind), underwater noise, vessel collisions, and port buildout.

- Receptors included birds & bats plus marine mammals, fish, sea turtles, etc.

- A range of monitoring and mitigation strategies were identified, along with primary challenges.

Stressors	Receptors
Attraction	Bats
Avoidance	Birds: In general; Migratory; Seabirds; Shorebirds
Barrier effect	Ecosystem level
Cumulative effects	Fish: In general; Diadromous; Prey fish and prey populations
Decommissioning / Repowering	Food webs
Displacement	Habitat: In general; Benthic habitat and communities; Pelagic habitat and communities; Shorelines
Disturbance	
Mooring lines and entanglement (e.g., floating wind)	Hydrodynamics and oceanographic processes
Physical structures	Marine invertebrates
Port buildout	Marine mammals: In general; All cetaceans; Whales; Dolphins and porpoises
Turbine collision	Migrating animals
Underwater noise	Sea Turtles
Vessel collisions	

Monitoring Needs	Mitigation Strategies	Primary Challenges
· Monitoring of migratory populations	· Marine spatial planning, including to avoid cumulative effects	· **Environmental science:** In general; Mitigation effectiveness; Lack of consensus on monitoring; Lack of baseline data; Lack of data on impacts; Regional coordination of research; Dissemination of science
· Behavior and distributions (e.g., telemetry studies)	· Develop a strategy for decommissioning that minimizes harm	· **Financial:** In general; Funding for research; Costs for monitoring
· Monitor pilot projects	· Validate effectiveness of various noise reduction technologies and quieter foundation types	· **Regulatory:** In general; Inter-governmental partnering; Prioritization of environmental issues; Setting expected level of longer-term development; Insufficient time for pre-construction studies; Siting and mitigation; Commit developers to to longer-term monitoring
· Cetacean behavior in operational offshore wind farms	· Informed choice of substrate types, such as for scour protection	
· Improved benthic imagery		
· Monitor existing decommissioning operations to formulate best practices	· Mitigation strategies may be offsite, such as predator control at nesting islands	· **Societal:** In general; Fishing industry considerations; Social acceptance; Value of different species; Workforce training; Marine spatial planning
· Design and implement large-scale, cross-receptor studies	· Model-based effective curtailment (if necessary)	
· High-resolution tracking in vicinity of structures and cables	· Environmentally-friendly siting tools	
· Real-time measurements across marine mammal species (vocalizing, non-vocalizing, deep diving)		

Figure 6. **OSW Priorities from Q2**

- Stressors
  - Cumulative effects (29%)
  - Turbine collisions (15%)
  - Displacement (14%); Noise (14%)
- Birds
  - Seabirds (53%)
  - "Birds in general" (34%)
  - Migratory birds (13%)
- Marine Mammals
  - "Marine mammals in general" (60%)
  - Cetaceans (29%)
  - Whales (8%)
  - Dolphins and Porpoises (3%)
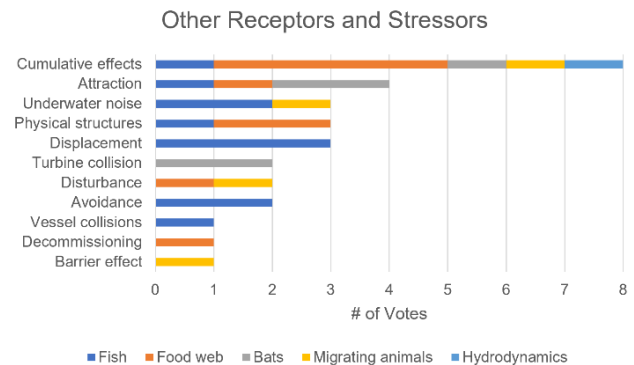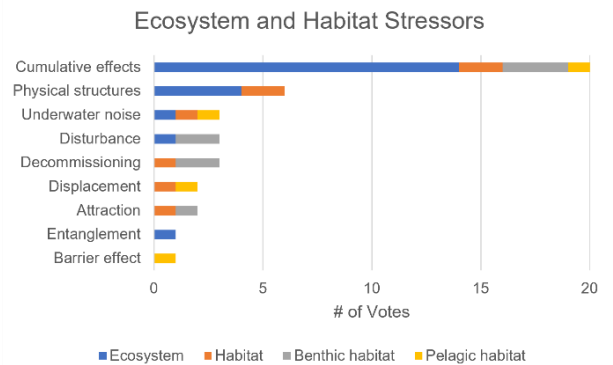- Ecosystems & Habitat
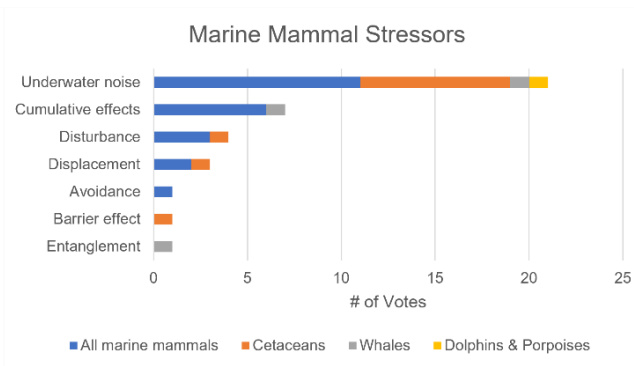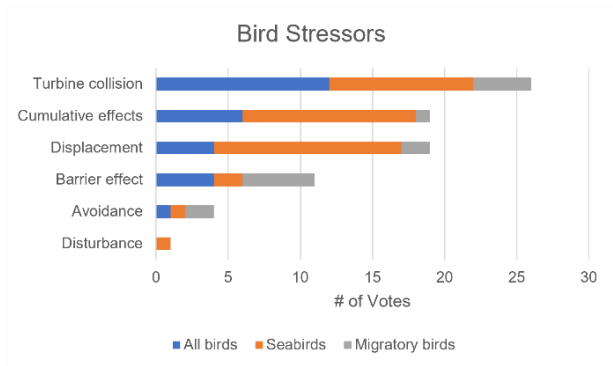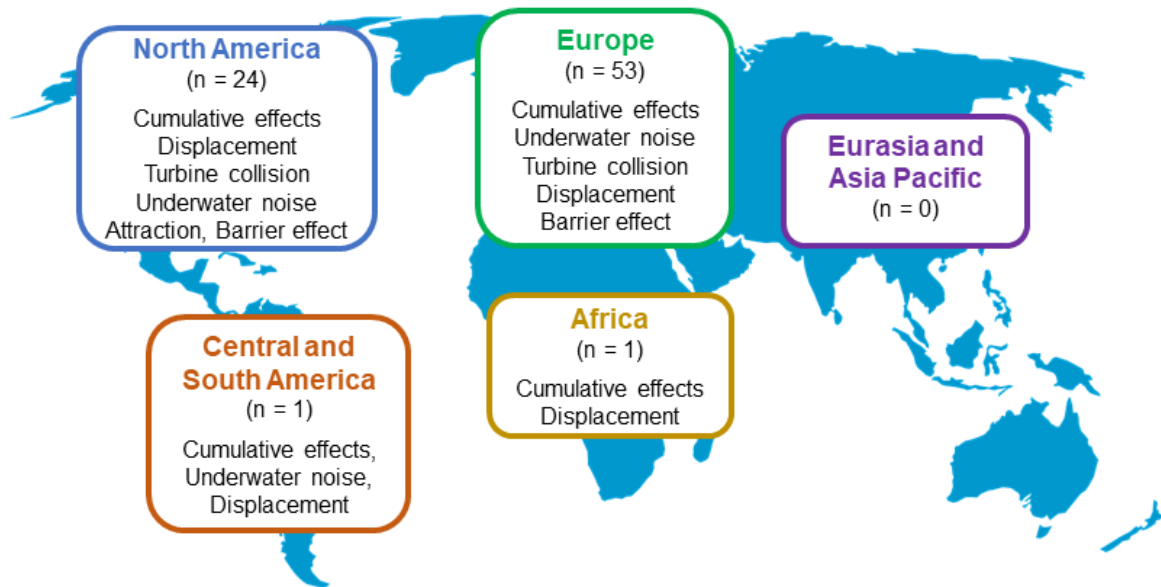- Other: Fish, Food web, etc.

Figure 7. OSW Stressors by Region

- Cumulative effects highest ranked stressor across regions
- Europe
  - Cumulative effects (31%)
  - Underwater noise (16%)
  - Turbine collision (13%)
  - Displacement (10%)
  - Barrier effect (9%)
- North America
  - Cumulative effects (25%)
  - Displacement (21%)
  - Turbine collision (19%)
  - Underwater noise (11%)
  - Attraction (5%), Barrier effect (5%)

North America
(n = 24)

Cumulative effects
Displacement
Turbine collision
Underwater noise
Attraction, Barrier effect

Europe
(n = 53)

Cumulative effects
Underwater noise
Turbine collision
Displacement
Barrier effect

Eurasia and Asia Pacific
(n = 0)

Central and South America
(n = 1)

Cumulative effects,
Underwater noise,
Displacement

Africa
(n = 1)

Cumulative effects
Displacement

Open Discussion: Panel and Participant on Offshore Wind Environmental Issues

- **Panelists:**
  - Lydie Couturier (Research Fellow-interactions between fish and OSW, France Énergies Marines)
  - Bob Rumes (Researcher and Policy Advisor for Offshore Renewables, Royal Belgian Institute of Natural Sciences)

- **Questions:**
  - Based on your experience, for your country, which of these environmental issues are a priority?
  - What do you perceive as the challenges to implementing monitoring and mitigation strategies?
  - What are the opportunities for moving forward and resolving these issues?
  - What geographic differences between North America and Europe would you like to highlight?

WREN Priority Assessment

Key Outcomes

- Approach was effective in identifying priorities

- Examples of priority **stressors** identified

  – *Turbine collisions* (LBW & OSW) – More data & improved methods (e.g., detection and deterrence technologies) needed for both birds & bats, including at larger turbines.

  – *Cumulative effects* (LBW & OSW) – Future development across multiple projects on birds, bats, ecosystems, marine mammals, etc.; Fixed & floating platforms.

  – *Indirect effects* – *Avoidance & Displacement (LBW & OSW)* – Understanding behavioral responses across scales including the wind farm, within wind farm, & at the turbine.

  – *Underwater noise (OSW)* – Methods for monitoring & minimizing effects across a range of marine life, including marine mammals, fish, & sea turtles.

- Examples of priority **receptors** identified

  – *LBW* – "Birds in general"; Raptors and Eagles; Soaring birds; "Bats in general"; Tree roosting bats; Ecosystems; Habitat; Animal Populations

  – **OSW** – Seabirds, "Birds in general", Migratory birds, "Marine mammals in general", Cetaceans, Whales, Ecosystems, Habitat, Fish, Food web

Credit: Audubon

WREN Priority Assessment

Key Outcomes

- Truly "emerging" considerations
  - Future technologies such as larger turbines and floating turbines
  - Potentially new stressors and species in frontier regions
  - Cumulative effects for multiple projects at a regional scale
  - Specific responses
    - Effects of disturbance on stress, communication, and fitness
    - Population impact methods still under development
    - Types of attraction have not been fully explored (e.g., bats)
    - Barrier effects, sometimes on a national scale for migrating flying animals
    - Provision of artificial habitat and effects on hard-bottom species connectivity and regional dynamics (both invasive / native)
    - Impact of development on forage resources for marine wildlife
    - Long-term impact on hydrodynamics and pelagic communities
    - Climate Change – discerning effects in an already changing environment

Illustration by Joshua Bauer, NREL

WREN Priority Assessment

Next Steps

- **Submitted Revised Manuscript**

    - Journal *Global Sustainability*

- **Dissemination:**

    - Presented at Conference on Wind Energy and Wildlife Impacts (CWW) – April 2022

    - WREN Webinar – Late June 2022

    - Recorded webinar & publication posted on Tethys (https://tethys.pnnl.gov)

- **Future Priorities:** Use findings to inform WREN and broad international science priorities, including expanded global outreach and partnerships.

Credit: NOAA

Questions

Thank you

www.nrel.gov

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