Floating wind turbines, such as these two en route to the world's first floating wind farm, could affect the environment in ways that have not yet been identified.

PHOTO: TERJE AASE/SHUTTERSTOCK

Edited by **Jennifer Sills**

Offshore renewables need an experimental mindset

The development of floating wind turbines that can operate in deep, offshore waters has unlocked tremendous energy generation potential (*1*). Existing floating offshore wind turbines, however, are still in demonstration phases. Because only about 10 turbines exist worldwide (*2*), their short- and long-term environmental impacts are still largely unknown. Floating wind turbines are likely to come with their own set of unique risks (*3*), which could include secondary entanglement of marine life in debris ensnared on stabilizing mooring lines (*4*), increased collision potential due to three-dimensional turbine movement (*5*), and benthic habitat degradation from turbine infrastructure such as anchors and buried interarray cables (*6*).

Despite potential impacts, countries are rapidly moving toward full commercial installations. The United States is advancing toward a lease sale for two areas in central and northern California and proposing floating wind turbines as a primary technology for the Gulf of Mexico (*7*). Floating wind turbines are also planned for the Gulf of Maine (*8*) and likely for New York (*9*). European and Asian countries have similar expansions planned (*2*).

Countries need robust plans to prevent, monitor, and mitigate the environmental impacts of floating wind turbines. We urge energy authorities and lawmakers to treat each installation as an experiment to gather information about the costs and benefits of this fledgling technology (*10*). Like any experiment, a comprehensive monitoring scheme is required to collect data, ideally for several years before turbines are first placed and then through the construction, lifetime operations, and decommissioning of the turbines (*11*). A robust monitoring plan with funding secured across all phases will help distinguish effects of floating wind development from other factors, such as climate change. Although it is tempting to focus only on the positives of clean energy, it is crucial to think preemptively about the longer-term impacts of floating wind turbines and use adaptive management practices to minimize impacts accordingly if necessary (*12*). Prevention rather than cure will be essential for the long-term sustainable success of this exciting, yet unknown, new sector.

Andrew F. Johnson[1,2]*, Cyndi L. Dawson[3], Melinda G. Conners[4], Cameron C. Locke[5], Sara M. Maxwell[5]

[1]MarFishEco Fisheries Consultants Ltd, Edinburgh, Scotland, UK. [2]Marine Sustainability, Policy & Conservation Evidence (Marine SPACE) Group, The Lyell Centre, Institute of Life and Earth Sciences, School of Energy, Geoscience, Infrastructure and Society, Heriot-Watt University, Edinburgh, Scotland, UK. [3]Castalia Environmental, Santa Cruz, CA 95062, USA. [4]School of Marine and Atmospheric Sciences, Stony Brook University, Stony Brook, NY 11794, USA. [5]School of Interdisciplinary Arts and Sciences, University of Washington, Bothell, WA 98011, USA.
*Corresponding author.
Email: andrew@marfisheco.com

REFERENCES AND NOTES

1. P. Rosa-Aquino, "Floating wind turbines could open up vast ocean tracts for renewable power," *The Guardian* (2021).
2. J. Lee., F. Zhao, "Global Offshore Wind Report," *Global Wind Energy Council* (2021).
3. S. M. Maxwell *et al*., *J. Environ. Manage*. **307**, 114577 (2022).
4. S. Benjamins *et al.*, "Understanding the potential for marine megafauna entanglement risk from marine renewable energy developments," Scottish Natural Heritage Commissioned Report No. 791 (2014), p. 95.
5. H. Bailey, K. L. Brookes, P. M. Thompson, *Aquat. Biosyst*. **10**, 8 (2014).
6. H. K. Farr *et al*., *Ocean Coast. Manage*. **207**, 105611 (2021).
7. Bureau of Ocean Energy Management, "BOEM hosts second Gulf of Mexico Renewable Energy Task Force meeting" (2022); www.boem.gov/newsroom/notes-stakeholders/boem-hosts-second-gulf-mexico-renewable-energy-task-force-meeting.
8. State of Maine Governor's Energy Office, "Gulf of Maine floating offshore wind research array" (2021); www.maine.gov/energy/initiatives/offshorewind/researcharray.
9. New York State Energy Research and Development Authority, "Governor Hochul announces nation leading $500 million investment in offshore wind" (2022); www.nyserda.ny.gov/About/Newsroom/2022-Announcements/2022-01-05-Governor-Hochul-Announces-Nation-Leading-500-Million-Investment-in-Offshore-Wind.
10. B. Snyder, M. J. Kaiser, *Renew. Energ*. **34**, 1567 (2009).
11. A. Giron-Nava *et al*., *Mar. Ecol. Prog. Ser*. **572**, 269 (2017).
12. A. Copping, V. Gartman, R. May, F. Bennet, in *Wind Energy and Wildlife Impacts: Balancing Energy Sustainability with Wildlife Conservation*, R. Bispo, J. Bernardino, H. Coelho, J. Lino Costa, Eds. (Springer International Publishing, 2019), pp. 1–25.

COMPETING INTERESTS

A.F.J. was funded by the Natural Resources Defense Council to consult on the environmental and fishery impacts of floating offshore wine turbines.

10.1126/science.abo7924

Green energy threatens Chile's Magallanes Region

On 2 December 2021, Chile's minister of energy and mining announced the country's largest green hydrogen project, to be developed in Chile's southernmost Magallanes Region (*1*–*3*). The project is intended to help achieve Chile's stated goal of generating 25 GW of green hydrogen by 2030 (*1*, *4*). However, enthusiasm for clean energy projects obscures their environmental and cultural impacts.

Despite the potential benefits, the large scale of this green hydrogen megaproject,

particularly its wind farms, could have an outsized effect on both ecological processes and the surrounding landscape. San Gregorio and Tierra del Fuego form part of important migration routes of threatened birds such as the ruddy-headed goose, the red knot, and the Magellanic plover (*5*), which fly across Patagonia on their way to their austral summer areas. Replacing sheep ranching with wind generation plants also entails a profound cultural change, comparable to the changes brought about by the arrival of European immigrants and inhabitants of the Chiloé archipelago and the subsequent development of sheep ranching in Magallanes at the end of the 19th century, which reconfigured social relations and land use in the region (*6*, *7*).

Preliminary estimates based on a pilot project in Punta Arenas (*3*) suggest that the megaproject could reach about 2900 installed wind turbines by 2027, occupying an area of at least 150,000 hectares. This would represent a 320% increase in Chile's wind energy generation capacity and would represent 1.35% of the wind energy installed in the world [relative to 2021 data (*8*)]. Recent studies in central Chile show a rate of 0.6 to 1.8 bird collisions per wind turbine per year (*3*). Scaling this to the magnitude of the planned Magallanes project could lead to between 1740 and 5220 bird collisions per year. However, this estimate does not consider that the Magallanes Region is a migration area for about 43 species of birds, including Passeriformes, Charadriiformes, and Strigiformes (*5*, *9*), which would likely increase these numbers.

Environmental impact assessments of these projects must take into consideration the high natural value of this landscape, with protected areas such as Torres del Paine National Park, Pali Aike National Park, and Bahía Lomas Ramsar site and Nature Sanctuary (*10*). Failing to do so could turn the development of clean energy megaprojects into another example of extractivist development (*11*), which would export a product (green hydrogen) to Europe and Asia while generating potentially irreversible changes to the local environment and culture.

Heraldo V. Norambuena[1]*, Fabio A. Labra[2], Ricardo Matus[1,3], Humberto Gómez[4], Diego Luna-Quevedo[5], Carmen Espoz[1]

[1]Centro Bahía Lomas, Facultad de Ciencias, Universidad Santo Tomás, Concepción Chile. [2]Centro de Investigación e Innovación para el Cambio Climático, Facultad de Ciencias, Universidad Santo Tomás, Santiago, Chile. [3]Centro de Rehabilitación de Aves Leñadura, Punta Arenas, Chile. [4]Agrupación Ecológica Patagónica, Punta Arenas, Chile. [5]Western Hemisphere Shorebird Reserve Network Executive Office–Manomet, Plymouth, MA 02360, USA.
*Corresponding author.
Email: hnorambuena@santotomas.cl

REFERENCES AND NOTES

1. Ministerio de Energía, "El más grande de Chile: Ministro Jobet anuncia nuevo proyecto de hidrógeno verde en Magallanes" (2021); https://energia.gob.cl/noticias/nacional/el-mas-grande-de-chile-ministro-jobet-anuncia-nuevo-proyecto-de-hidrogeno-verde-en-magallanes [in Spanish].
2. Highly Innovative Fuels, "Capítulo 1: Descripción de proyecto—Proyecto piloto de descarbonización y producción de combustibles carbono neutral, declaración de impacto ambiental," Tech. Rep. N° 2020-12-31 (2020); https://infofirma.sea.gob.cl/DocumentosSEA/MostrarDocumento?docId=6e/7c/7dcdd2b1c3afdfbd2f257113b0281c634710 [in Spanish].
3. República de Chile, Comisión de Evaluación, Región de Magallanes y Antártica Chilena, "Califica ambientalmente el proyecto: Proyecto piloto de descarbonización y producción de combustibles carbono neutral" (Resolución de Calificación Ambiental N°58, 2021) [in Spanish].
4. Ministerio de Energía, "Transición energética de Chile, política energética nacional" (Gobierno de Chile, 2021) [in Spanish].
5. F. Medrano, R. Barros, H. V. Norambuena, R. Matus, F. Schmitt, Eds., *Atlas de las Aves Nidificantes de Chile* (Red de Observadores de Aves y Vida Silvestre de Chile, Santiago, Chile, 2018) [in Spanish].
6. J. Calderón, *Boletín del Ministerio de Agricultura* **10**, 1 (1936) [in Spanish].
7. R. Urbina, in *Planning Outlook Series 1* (1956), vol. 4, p. 22.
8. Global Wind Energy Council, Global wind report 2021 (2021); https://gwec.net/global-wind-report-2021/.
9. eBird: An online database of bird distribution and abundance [web application] (Cornell Lab of Ornithology, Ithaca, New York, 2022); https://ebird.org/chile/barcharт?byr=1900&eyr=2022&bmo=1&emo=12&r=CL-MA.
10. Comisión Nacional del Medio Ambiente Chile, "Diagnóstico y propuesta para la conservación de la biodiversidad en la xii región" (2002) [in Spanish].
11. M. A. Urbina *et al.*, *Science* **373**, 1208 (2021).

10.1126/science.abo4129

Brazilian pesticides law could poison the world

Brazil's National Congress will soon vote on a controversial bill (PL 6299/2002) that relaxes the current legislation on pesticides (*1*). Arguing that the registration of new products takes too long, this bill proposes changes to the evaluation and authorization process, excluding the health and environment federal agencies from the decision. In addition, previously banned substances could then be reevaluated under these new rules. This bill fits Brazil's recent trend of undermining environmental law (*2*) by prioritizing the productive sector to the detriment of environmental integrity (*3*, *4*).

In 2021, the government authorized the use of 562 new agrochemicals in Brazil (*5*), many of them imported from Europe and North America (*6*). Several of those new pesticides are banned in these countries (*6*, *7*), but their manufacturers continue exporting them to places with permissive legislation like Brazil. The indiscriminate use of pesticides without proper evaluation is a matter of public health. In the past 10 years, intoxication and deaths related to pesticide poisoning increased by 94% in Brazil (*8*), and those pesticides persist in the environment (*9*).

Because Brazil is a leader in exporting its crops, such as soy that supplies global animal feed (*10*), the likely approval of this bill should be a global concern. More pesticides are not necessary to feed the world (*11*). There are well-known solutions to enhance productivity (*12*) that do not require the intense use of pesticides, such as agroecology (*11*). An alternative bill (PL 6670/2016) could move Brazil in a better direction by initiating a national program to reduce pesticides, but this proposal has been given low priority and is unlikely to become law under the current administration. Strengthening environmental agencies and investing in science and technology is the way to achieve the sustainable development of agribusiness.

Laís Carneiro[1]*, Larissa Faria[1], Natali Miiller[1], André Cavalcante[1], Afonso Murata[2], Jean Ricardo Simões Vitule[1]

[1]Laboratório de Ecologia e Conservação, Setor de Tecnologia, Departamento de Engenharia Ambiental, Universidade Federal do Paraná, Curitiba, PR, 81531-970, Brazil. [2]Centro de Ensino Pesquisa e Extensão em Agroecologia, Departamento de Fitotecnia e Fitossanidade, Universidade Federal do Paraná, Curitiba, PR, 81531-970, Brazil.
*Corresponding author.
Email: lais.olicar@gmail.com

REFERENCES AND NOTES

1. Agência de Notícias, "Câmara aprova projeto que altera regras de registro de agrotóxicos." (2022); www.camara.leg.br/noticias/849479-camara-aprova-projeto-que-altera-regras-de-registro-de-agrotoxicos/ [in Portuguese].
2. L. G. Barbosa, M. A. S. Alves, C. E. V. Grelle, *Land Use Pol.* **104**, 105384 (2021).
3. P. Charvet *et al.*, *Science* **371**, 356 (2021).
4. F. E. Coelho, L. C. Lopes, R. M. S. Cavalcante, G. C. Corrêa, A. O. H. C. Leduc, *Science* **365**, 552 (2019).
5. Brazil, Ministry of Agriculture, "Registros concedidos 2000–2022" (2022); www.gov.br/agricultura/pt-br/assuntos/insumos-agropecuarios/insumos-agricolas/agrotoxicos/RegistrosConcedidos20002022.xlsx [in Portuguese].
6. L. M. Bombardi, *Geografia do Uso de Agrotóxicos No Brasil e Conexões com a União Europeia* (Faculdade de Filosofia, Letras e Ciências Humanas, Universidade de São Paulo, 2017) [in Portuguese].
7. "PAN International consolidated list of banned pesticides," Pesticide Action Network International (2021); https://pan-international.org/pan-international-consolidated-list-of-banned-pesticides/.
8. R. J. Buralli, F. N. E. F. de Souza, "Mortality and morbidity by work-related pesticide poisoning in Brazil, 2009–2019," ISEE Conference Abstracts 2021 (2021).
9. I. E. Barnhoorn, M. S. Bornman, C. J. Van Rensburg, H. Bouwman, *Chemosphere* **77**, 1236 (2009).
10. C. Dowler, "Soya, corn, and cotton make Brazil world leader for hazardous pesticides," *Unearthed* (2020); https://unearthed.greenpeace.org/2020/02/20/brazil-pesticides-soya-corn-cotton-hazardous-croplife/.
11. "Report of the Special Rapporteur on the right to food," United Nations A/HRC/34/48 (2017).
12. M. Lykogianni, E. Bempelou, F. Karamaouna, K. A. Aliferis, *Sci. Tot. Environ.* **795**, 148625 (2021).

10.1126/science.abo6942

Offshore renewables need an experimental mindset

Andrew F. JohnsonCyndi L. DawsonMelinda G. ConnersCameron C. LockeSara M. Maxwell

Science, 376 (6591), • DOI: 10.1126/science.abo7924