AFRAID FOR THE DARK: REGULATING LIGHT POLLUTION UNDER THE CLEAN WATER ACT

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INTRODUCTION

> *"I am no longer so much afraid of the dark as I am afraid for the dark."*
>
> —Paul Bogard[1]

We slouch over our laptops by lamp light long after everyone has gone to bed; we whip up a late-night snack under harsh kitchen lights; we travel home late along streetlight-lined highways; and we grab that forgotten item from the twenty-four-hour convenience store, bathed in a neon glow. Human ingenuity has surmounted dependence on solar and lunar cycles, enabling anyone to do nearly anything at any given time. This feat is attributable to one humble but miraculous thing: artificial light. Modern society would surely collapse if we returned to a schedule of sunrise-to-sunset, with nothing but a candle to cast away shadows. Yet, in the glare of an ever-brighter night, are we blind to the consequences of artificial light upon non-human life?

The DarkSky defines light pollution as the "human-made alteration of outdoor light levels."[2] Like traditional forms of air, water, and land pollution, light pollution has consequences for humans, wildlife, and the climate.[3] Not all light, of course, is pollutive. Light pollution comprises light that is "inefficient, overly bright, poorly targeted, improperly shielded, and, in many cases, completely unnecessary."[4] The adverse effects of light pollution are well-founded, including circadian rhythm disorientation, energy waste, and ecosystem disturbance.[5] Only recently, however, have

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1. Paul Bogard, *Introduction: Why Dark Skies?*, *in* LET THERE BE NIGHT: TESTIMONY ON BEHALF OF THE DARK 1, 2 (Paul Bogard ed., 1st ed. 2008).

2. *What is Light Pollution?*, DARKSKY INT'L, https://www.darksky.org/resources/what-is-light-pollution/ [https://perma.cc/AG5E-XQK2].

3. *Id.*

4. *What is Light Pollution?*, DARKSKY MICH., https://darkskymichigan.org/what-is-light-pollution%3F [https://perma.cc/F4XS-BU2Z].

5. D. Eric Lystrup, *The Dark Side of the Light: Rachel Carson, Light Pollution, and a Case for Federal Regulation*, 57 JURIMETRICS 505, 511-12 (2017); Andrea L. Johnson, Note, *Blinded by the Light: Addressing the Growing Light Pollution Problem*, 2 TEX. A&M J. PROP. L. 461, 465 (2015).

researchers begun to illuminate the detrimental impact of light pollution on marine ecosystems.[6]

Artificial light at night (ALAN), the primary source of light pollution, is detectable along at least 22 percent of the world's coasts and predicted to "dramatically increase as coastal human populations more than double by year 2060."[7] In 2021, international scientists prepared the first global atlas of the sea floor, enabling quantification of ALAN's pervasiveness in coastal ecosystems.[8] The study revealed that 1.9 million square kilometers of coastal waters in the world are exposed to "biologically important ALAN"—defined as "irradiances sufficient to elicit biological responses" in marine organisms—to a depth of one meter, depending on water clarity.[9] Most instances of biologically important ALAN are found in regions with both intensive offshore development and coastal urbanization.[10] Offshore energy production, which includes oil and gas platforms, wind farms, and marine energy, releases extensive

6. *See* Thomas W. Davies, James P. Duffy, Jon Bennie & Kevin J. Gaston, *The Nature, Extent, and Ecological Implications of Marine Light Pollution*, 12 FRONTIERS ECOLOGY & ENV'T 347, 347 (2014) ("Despite centuries of use, artificial light at night has only recently been recognized as a cause for environmental concern.").

7. Thomas W. Davies, David McKee, James Fishwick, Svenja Tidau & Tim Smyth, *Biologically Important Artificial Light at Night on the Seafloor*, 10 SCI. REPS. 1, 1 (2020); *see* John C. Barentine, *Who Speaks for the Night? The Regulation of Light Pollution in the 'Rights of Nature' Legal Framework*, 22 INT'L J. SUSTAINABLE LIGHTING 28, 28 (2020); Barbara Neumann, Athanasios T. Vafeidis, Juliane Zimmermann & Robert J. Nicholls, *Future Coastal Population Growth and Exposure to Sea-Level Rise and Coastal Flooding—A Global Assessment*, 10 PLOS ONE 1, 1 (2015).

8. T.J. Smyth, A.E. Wright, D. McKee, S. Tidau, R. Tamir, Z. Dubinsky, D. Iluz & T.W. Davies, *A Global Atlas of Artificial Light at Night Under the Sea*, 9 ELEMENTA SCI. ANTHROPOCENE 1, 1-2 (2021).

9. *See id.* at 1, 8; Davies et al., *supra* note 6, at 347.

10. *See* Smyth et al., *supra* note 8, at 1.

marine light pollution.[11] Shipping and fishing lights can also disrupt certain marine species up to 200 meters deep.[12]

Currently, light pollution is only regulated at the state and local level. However, not all states implement legislation to mitigate the adverse effects of ALAN.[13] Nineteen states, the District of Columbia, and Puerto Rico have implemented laws to reduce light pollution.[14] In states without such laws, or in federal waters, light-intensive activities remain unchecked. The rapid increase in light pollution in recent years illustrates the inadequacies of existing state and local regulatory schemes and calls for a new understanding of ALAN as a pollutant to marine ecosystems.[15]

This Note argues that the existing tools in the Clean Water Act (CWA, or "the Act") provide authority for the U.S. Environmental Protection Agency (EPA) to regulate light pollution and preserve the integrity of the nation's waters.[16] Part I examines the existing body

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11. Sara E. Pratt, *Bathed in a Sea of Artificial Light*, NASA EARTH OBSERVATORY, https://earthobservatory.nasa.gov/images/149518/bathed-in-a-sea-of-artificial-light [https://perma.cc/K5HP-7E8J]; *Marine Energy Basics*, U.S. DEP'T OF ENERGY, https://www.energy.gov/eere/water/marine-energy-basics [https://perma.cc/F4Q9-JNFQ] ("Marine energy ... is a renewable power source that is harnessed from the natural movement of water, including waves, tides, and river and ocean currents."); Caroline E. Reilly, Julia Larson, Alicia M. Amerson, Garrett J. Staines, Joseph H. Haxel & Paul Morgan Pattison, *Minimizing Ecological Impacts of Marine Energy Lighting*, 10 J. MARINE SCI. & ENG'G 1, 1 (2022) ("One stressor marine energy installations introduce is light, which is known to cause varying responses among wildlife and has not yet been addressed as an environmental concern."). *See generally* TERRY L. ORR, SUSAN M. HERZ & DARRELL L. OAKLEY, U.S. DEPT. OF INTERIOR, BUREAU OF OCEAN ENERGY MGMT., OFF. RENEWABLE ENERGY PROGRAMS, EVALUATION OF LIGHTING SCHEMES FOR OFFSHORE WIND FACILITIES AND IMPACTS TO LOCAL ENVIRONMENTS (2013).

12. Jørgen Berge, Maxime Geoffroy, Malin Daase, Finlo Cottier, Pierre Priou, Jonathan H. Cohen, Geir Johnsen, David McKee, Ina Kostakis, Paul E. Renaud, Daniel Vogedes, Philip Anderson, Kim S. Last & Stephane Gauthier, *Artificial Light During the Polar Night Disrupts Arctic Fish and Zooplankton Behaviour Down to 200 m Depth*, 3 COMMC'NS BIOLOGY 1, 5 (2020) (concluding that "artificial light caused an almost immediate response [for species] throughout the entire water column down to [a depth of 200 meters] and up to 200 [meters] away from the ship").

13. *See* Jennifer Schultz, *States Shut Out Light Pollution*, NAT'L CONF. OF STATE LEGISLATURES (Mar. 25, 2022), https://www.ncsl.org/environment-and-natural-resources/states-shut-out-light-pollution [https://perma.cc/6FCV-X2TF].

14. *Id.*

15. *See* Kristen M. Ploetz, Note, *Light Pollution in the United States: An Overview of the Inadequacies of the Common Law and State and Local Regulation*, 36 NEW ENG. L. REV. 985, 987 (2002); *see also* Lystrup, *supra* note 5, at 520.

16. *See* 33 U.S.C. § 1251(a) ("The objective of [the CWA] is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters.").

of research on ALAN's damage to marine and wetland ecosystems. Part II surveys the insufficiency of existing state and local regulation of light pollution. Part III addresses the need for federal regulation of light pollution through ALAN's classification as a pollutant under the CWA. Part III also confronts counterarguments to recent concerns about regulatory overreach in the wake of *West Virginia v. EPA*.

I. SHEDDING LIGHT ON LIGHT POLLUTION

This Part tours the development of artificial light and surveys the threat of unbridled light pollution. Section A covers the origins of light and the evolution of light pollution. Section B examines recent scholarship exploring the harms of light pollution to aquatic ecosystems and their inhabitants that diminishes the integrity and longevity of the nation's waters.

A. From Flicker to Glare: The History and Expansion of Light Pollution

The nineteenth century welcomed the first uses of electric light, culminating in the advent of the light bulb in 1879.[17] Artificial light is now one of the most ubiquitous technologies, with global light emissions observable by satellite increasing at least 49 percent between 1992 to 2017.[18] This leap is largely attributable to the rise in broad spectrum, light-emitting diode (LED) technology.[19] In 2014, the inventors of LED technology received the Nobel Prize in Physics for discovery of the bright blue light.[20] The amplification of LED light today plays an important role in combating climate change, reducing overall energy consumption from lighting by up to 90

17. *See* Ploetz, *supra* note 15, at 988.

18. Alejandro Sánchez de Miguel, Jonathan Bennie, Emma Rosenfeld, Simon Dzurjak & Kevin J. Gaston, *First Estimation of Global Trends in Nocturnal Power Emissions Reveals Acceleration of Light Pollution*, 13 REMOTE SENSING 3311, 3311 (2021).

19. *Id.*

20. Sumeet Kulkarni, *How an Effort to Reduce Fossil Fuel Use Led to Another Environmental Problem: Light Pollution*, L.A. TIMES (Sept. 20, 2022, 5:00 AM), https://www.latimes.com/science/story/2022-09-20/how-an-effort-to-reduce-fossil-fuel-use-led-to-another-environmental-problem-light-pollution [https://perma.cc/2VZS-8LHZ].

percent compared to its incandescent counterparts.[21] However, this switch has catalyzed an unexpected externality: the rapid rise of light pollution.[22]

LED light is thought to increase radiance in the visible spectrum as high as 270 percent globally, and 400 percent in specific regions.[23] Simply put, LED light is both brighter and reaches farther than its older counterparts. Unlike the orange-red hue emitted from incandescent, or low-pressure sodium (LPS) lighting, LED lighting falls on the blue end of the visible spectrum and penetrates deeper into the water column, making the rise in LED use a notable concern for marine ecosystems.[24] Undoubtedly, LED light is a crucial development in efficient energy consumption, but we must not forget its externalities that require thoughtful solutions to excessive and unnecessary light.[25]

There are four classifications of light pollution identified by DarkSky Internsational: (1) glare, defined as "excessive brightness that causes visual discomfort;" (2) skyglow, defined as the "brightening of the night sky over inhabited areas;" (3) light trespass, defined as "light falling where it is not intended or needed;" and (4) clutter, defined as "bright, confusing, and excessive groupings of light sources."[26] Of these classifications, skyglow and glare are of greatest concern for marine behaviors.[27] Skyglow occurs when ALAN from coastal cities, oil platforms, and other offshore structures disseminates throughout the atmosphere and extends the reach of light pollution hundreds of kilometers from the source into the waters of

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21. *Id.* (stating that LEDs require less than 25 percent of the energy used by an incandescent lamp); *see Learn About LED Lighting*, ENERGY STAR, https://www.energystar.gov/products/lighting_fans/light_bulbs/learn_about_led_bulbs [https://perma.cc/3UVE-GW6K].

22. *See* Kulkarni, *supra* note 20 ("And yet the public's embrace of LEDs keeps rising, spilling way too much light into the sky where no one needs it.").

23. *See* Sánchez de Miguel et al., *supra* note 18, at 3311; *see also* Smyth et al., *supra* note 8, at 9.

24. Smyth et al., *supra* note 8, at 10. *See generally Why Do We Explore the Water Column?*, NAT'L OCEANIC & ATMOSPHERIC ADMIN., https://oceanexplorer.noaa.gov/facts/water-column.html [https://perma.cc/8Q94-L2N2] ("[T]he water column ... includes all of the water in the ocean between the surface and the seafloor.").

25. *See LED Lighting*, U.S. DEP'T OF ENERGY, https://www.energy.gov/energysaver/led-lighting [https://perma.cc/RYN4-PLCP] ("The [LED] is today's most energy-efficient and rapidly-developing lighting technology.").

26. *What is Light Pollution?*, *supra* note 2.

27. *See* Smyth et al., *supra* note 8, at 1.

surrounding marine ecosystems, whereas glare comes from more direct sources of light and causes annoyance, discomfort, or loss in visual performance.[28]

Despite the evident benefits of ALAN, a growing body of research casts light on the ecological impacts of light pollution.[29] Much of this research has focused on land-based impacts to humans and wildlife. Among the most well-known examples of wildlife disruption due to light pollution is its fatal impact on sea turtle spawning: hatchlings are misled by artificial light on their risky journey to the sea, causing them to die from exhaustion, dehydration, or predation.[30] Birds too are highly susceptible and attracted to ALAN, which causes lethal collisions and alterations to their nesting and migratory behaviors.[31] Thorough scholarship indicates that human circadian rhythms and hormone levels are also disturbed by increases in artificial light.[32]

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28. *Id.*; *Glare*, ILLUMINATING ENG'G SOC'Y, https://www.ies.org/definitions/glare/ [https://perma.cc/9GKH-GVMU] (defining glare as "[t]he sensation produced by luminances within the visual field that are sufficiently greater than the luminance to which the eyes are adapted to cause annoyance, discomfort, or loss in visual performance or visibility").

29. *See* Thomas W. Davies, James P. Duffy, Jon Bennie & Kevin J. Gaston, *Stemming the Tide of Light Pollution Encroaching into Marine Protected Areas*, 9 CONSERVATION LETTERS 164, 164 (2016); Smyth et al., *supra* note 8, at 1; Berge et al., *supra* note 12, at 1; Barentine, *supra* note 7, at 28.

30. *See* Ploetz, *supra* note 15, at 998; *see also* Johnson, *supra* note 5, at 465.

31. *See* Ploetz, *supra* note 15, at 997-98; *see also* Sibylle Schroer, Benedikt John Huggins, Clementine Azam & Franz Hölker, *Working with Inadequate Tools: Legislative Shortcomings in Protection Against Ecological Effects of Artificial Light at Night*, 12 SUSTAINABILITY 2551, 2565 (2020).

32. *See* Ploetz, *supra* note 15, at 1000; Ron Chepesiuk, *Missing the Dark: Health Effects of Light Pollution*, 117 ENV'T HEALTH PERSPS. 20, 24-27 (2009); *AMA Adopts Guidance to Reduce Harm from High Intensity Street Lights*, AM. MED. ASS'N (June 14, 2016), https://www.ama-assn.org/press-center/press-releases/ama-adopts-guidance-reduce-harm-high-intensity-street-lights [https://perma.cc/6D27-LQCX] ("It is estimated that white LED lamps have five times greater impact on circadian sleep rhythms than conventional street lamps. Recent large surveys found that brighter residential nighttime lighting is associated with reduced sleep times, dissatisfaction with sleep quality, excessive sleepiness, impaired daytime functioning and obesity.").

Until recently, however, the effects of light pollution on marine ecosystems remained largely understudied.[33] A staggering 23 percent of the global population lives within 100 kilometers of the coast, creating concentrations of light around human life and development.[34] Moreover, 75 percent of the world's megacities are situated in coastal regions, where populations are projected to double in fewer than four decades.[35] Some major sources of ALAN include shipping and fishing, offshore energy production, and land-based developments including residential and commercial lighting.[36] These permanent and temporary sources of light pollution alter the natural ecosystem, from which artificial skyglow obscures the subtle changes in the lunar cycle.[37]

A recent study of in-water ALAN skyglow transmission revealed that up to 76 percent of the seafloor adjacent to cities can be exposed to biologically important artificial light.[38] Over 1.9 million kilometers of coastal waters are impacted by ALAN at depths of one meter, and other significant portions of the ocean experience light exposures to depths of twenty meters or more.[39] This equates to roughly 3 percent of global Exclusive Economic Zones (EEZs), the 200 nautical miles off a country's coast.[40] Coupled with the population projections along the world's coastlines, light pollution reaching the seafloor will only become more intense and extensive.[41]

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33. Davies et al., *supra* note 29, at 164; Smyth et al., *supra* note 8, at 1; Martin Ludvigsen, Jørgen Berge, Maxime Geoffroy, Jonathan H. Cohen, Pedro R. De La Torre, Stein M. Nornes, Hanumant Singh, Asgeir J. Sørensen, Malin Daase & Geir Johnsen, *Use of an Autonomous Surface Vehicle Reveals Small-Scale Diel Vertical Migrations of Zooplankton and Susceptibility to Light Pollution Under Low Solar Irradiance*, 4 SCI. ADVANCES 1, 1 (2018).

34. *See* Davies et al., *supra* note 6, at 347; *see also* Davies et al., *supra* note 29, at 164; Smyth et al., *supra* note 8, at 1.

35. Davies et al.,, *supra* note 7, at 4.

36. Davies et al., *supra* note 29, at 164; Smyth et al., *supra* note 8, at 1; Dipika Kadaba, *Blinded by the Light Pollution*, REVELATOR (May 21, 2018), https://therevelator.org/ blinded-light-pollution/ [https://perma.cc/H8ZM-DQTG].

37. Davies et al., *supra* note 29, at 164-65; Smyth et al., *supra* note 8, at 1.

38. Davies et al., *supra* note 7, at 4.

39. *See* Pratt, *supra* note 11; Smyth et al., *supra* note 8, at 6.

40. *See* Pratt, *supra* note 11.

41. Davies et al., *supra* note 7, at 4.

B. Threats to the Integrity of Marine Ecosystems

Marine ecosystems and their inhabitants rely on natural light cycles as cues for their behaviors and biological functions.[42] The moon and stars serve as celestial guides for navigation, migration and mating patterns, and predator-prey relationships.[43] Even minor variations in light can disturb highly photosensitive marine organisms.[44]

Scientists have observed how subtle changes in lighting at night affect physiology, survival, reproduction, and movement of aquatic life.[45] Zooplankton and many types of fish across aquatic habitats undergo a process called "diel vertical migration" (DVM), guided by moonlight.[46] DVM is characterized by cyclic patterns of vertical movement synchronized with variations in irradiance.[47] Zooplankton DVM in particular is "the most widespread and synchronized movement of biomass on the planet and thus is one of the most important factors to consider for understanding marine food-web interactions and ecosystem structures."[48] Thus, DVM is a key component of predator-prey relationships, serving as a tactic to avoid light intensities favorable to visual predators. As such, these organisms often only come to the water's surface to forage during dark conditions.[49] Coral reefs similarly exhibit light-driven diel cycles or synchronize reproduction by monthly cycles, queued by

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42. Smyth et al., *supra* note 8, at 1; Pratt, *supra* note 11; Berge et al., *supra* note 12, at 1.

43. *See* Berge et al., *supra* note 12, at 1; Davies et al., *supra* note 6, at 347.

44. Davies et al., *supra* note 7, at 1; Pratt, *supra* note 11.

45. Davies et al., *supra* note 7, at 4-7. To name some examples, "*Calanus* copepods undergo diel vertical migration to depths of [fifty meters] guided only by variations in moonlight intensity during the Arctic winter; the larvae of some sessile invertebrates move and identify suitable settlement locations guided by light levels equivalent to moonless overcast nights; and polychaete worms, corals and echinoderms synchroni[z]e broadcast spawning events using monthly and annual variations in lunar light intensity." *Id.* at 1; *see also* Berge et al., *supra* note 12, at 1.

46. Davies et al., *supra* note 6, at 350; Ludvigsen et al., *supra* note 33, at 1.

47. Ludvigsen et al., *supra* note 33, at 1.

48. *Id.* at 4.

49. *See id.* at 1; TRAVIS LONGCORE & CATHERINE RICH, NAT'L PARK SERV., ARTIFICIAL NIGHT LIGHTING AND PROTECTED LANDS 6-7, 10 (2017) ("As a general rule, additional light—whether moonlight or anthropogenic light—increases foraging efficiency of predators and reduces activity of prey."); Davies et al., *supra* note 6, at 350.

subtle changes in lunar light.[50] ALAN disturbs these natural rhythms, resulting in "reduced reproductive success, disrupted migration, altered recruitment, and [shifted] balance of species interactions."[51]

Both ambient skyglow and more direct sources of glare can trigger responses in marine behaviors deep into the water column.[52] Zooplankton, tropical corals, and temperate marine organisms are shown to respond to artificial skyglow down to depths of seventy meters.[53] When exposed to a more direct light source, such as street lighting, these responses can be observed down to 100 meters.[54] Even more astounding, one study showed that fish and microzooplankton, a smaller variety of plankton, display an "almost instantaneous response" to artificial light as deep as 200 meters when exposed to a fully illuminated ship in Arctic waters.[55] A similar study also captured zooplankton's avoidance of artificial light from vessels, further demonstrating ALAN's impacts on key biological functions.[56] In the waters surrounding the world's mega-cities, ALAN dosage—the total amount of light received—exceeds that of the natural light from the moon found above and below the surface of the sea across all seasons.[57]

Moreover, there are climate implications from altering marine behaviors. Zooplankton DVM provides a mode of vertical transport

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50. *See* C. Aubrecht, C.D. Elvidge, T. Longcore, C. Rich, J. Safran, A.E. Strong, C.M. Eakin, K.E. Baugh, B.T. Tuttle, A.T. Howard & E.H. Erwin, *A Global Inventory of Coral Reef Stressors Based on Satellite Observed Nighttime Lights*, 23 GEOCARTO INT'L 467, 469 (2008); Maxim Y. Gorbunov & Paul G. Falkowski, *Photoreceptors in the Cnidarian Hosts Allow Symbiotic Corals to Sense Blue Moonlight*, 47 LIMNOLOGY & OCEANOGRAPHY 309, 314 (2002); O. Levy, L. Mizrahi, N. E. Chadwick-Furman & Y. Achituv, *Factors Controlling the Expansion Behavior of* Favia Favus *(Cnidaria: Scleractinia): Effects of Light, Flow, and Planktonic Prey*, 200 BIOLOGICAL BULL. 118, 118 (2001).

51. *See* Smyth et al., *supra* note 8, at 8 (citations omitted).

52. Davies et al., *supra* note 6, at 347-48.

53. Davies et al., *supra* note 7, at 1.

54. *Id.*

55. Berge et al., *supra* note 12, at 2, 5.

56. Ludvigsen et al., *supra* note 33, at 4.

57. T.J. Smyth, A.E. Wright, A. Edwards-Jones, D. McKee, A. Quierós, O. Rendon, S. Tidau & T.W. Davies, *Disruption of Marine Habitats by Artificial Light at Night from Global Coastal Megacities*, ELEMENTA SCI. ANTHROPOCENE 1, 1 (2022).

for millions of tons of organic carbon—a key process in the mitigation of climate change.[58] When aquatic animals return to deeper waters after feeding at the surface, their waste transports carbon to the ocean floor through a process called carbon sequestration.[59] Research indicates that the greatest direct impacts of light pollution "are likely on highly photosensitive species that utilize moonlight to guide migrations and synchronize phenological events, many of which are critical to the wider ecosystem and sustain vital ecosystem services."[60] These responses to artificial light are even stronger when marine organisms are exposed to white or blue LED light.[61] This indicates that ALAN may play a role in climate change because disturbances to DVM behaviors could impact the carbon cycle.[62]

A changing climate also risks exposing certain aquatic regions to increased light pollution. Above the Arctic Circle, marine organisms have evolved to live in near-total darkness.[63] In the darkness of the "Nautical Polar Night," marine organisms remain active, regulating their behavior using solar illumination that is virtually undetectable to the human eye.[64] In Arctic regions, zooplankton move up and down the water column by using the low levels of light from the sun, moon, and aurora borealis that penetrate the dense sea ice.[65]

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58. Kanchana Bandara, Øystein Varpe, Lishani Wijewardene, Vigdis Tverberg & Ketil Eiane, *Two Hundred Years of Zooplankton Vertical Migration Research*, 96 BIOLOGICAL REVS. 1547, 1547 (2021).

59. Allen Collins, *What Is Vertical Migration of Zooplankton and Why Does it Matter?*, NAT'L OCEANIC & ATMOSPHERIC ADMIN. (Oct. 28, 2021), https://oceanexplorer.noaa.gov/facts/vertical-migration.html [https://perma.cc/Z4AN-Y3Y4].

60. Smyth et al., *supra* note 8, at 8 (citations omitted).

61. Berge et al., *supra* note 12, at 2; Smyth et al., *supra* note 8, at 10.

62. *See* Collins, *supra* note 59.

63. Berge et al., *supra* note 12, at 1 ("[T]he moon, stars and aurora borealis may provide important cues to guide distribution and behaviours, including predator-prey interactions.").

64. *Id.* ("In a system where organisms remain active and are adapted to detect and respond to extremely low levels of natural light during the Polar Night, we postulate that their susceptibility towards artificial light is likely to be high. With a continued warming and reduction of Arctic sea ice, human presence and activity in the region are predicted to increase substantially."). While this study was conducted in Norway, Alaska possesses Arctic regions that are home to light pollution-inducing industries including oil and gas drilling and fishing. ENCYC. BRITANNICA, *Economy of Alaska*, https://www.britannica.com/place/Alaska/Economy [https://perma.cc/Q2M6-S9C7].

65. Chiara Eisner, *Arctic Exploitation May Harm Animals Large and Small*, SCI. AM. (Mar. 5, 2020), https://www.scientificamerican.com/article/arctic-exploitation-may-harm-animals-large-and-small/ [https://perma.cc/PRA6-YCV2]; Berge et al., *supra* note 12, at 1.

Today, light pollution is thought to be among the fastest growing sources of pollution in the Arctic region.[66] High light-emitting activities, including shipping, fishing, and energy production, are common types of human activity found in Arctic regions.[67] As waters warm and sea ice melts, certain marine species are traveling to higher latitudes.[68] Less sea ice will cause more light from ships, energy operations, and other developments to more easily pervade dark ocean waters, leaving arctic ecosystems further susceptible to changes in the complex food web.[69]

Because ALAN is often brighter and more intense than natural sources of light at night, no species has evolved to interact with light pollution.[70] The growing scientific consensus illuminating the impacts of ALAN should serve as notice to regulators that these aquatic communities face a significant threat that is likely to worsen in years to come.

II. EXISTING LIGHT POLLUTION REGULATION IS DIM

At present, light pollution is regulated at the state and local level.[71] Nineteen states, the District of Columbia, and Puerto Rico have implemented laws governing light pollution.[72] Several of these laws are classified as "dark skies" legislation, designed to encourage energy conservation, safety, aesthetic values, or astronomical research.[73] Counties and municipalities across the country have also

66. Berge et al., *supra* note 12, at 2.

67. *See id.*; *see also* Ludvigsen et al., *supra* note 33, at 1.

68. Sarah Gibbens, *Climate Change Is Leading to Arctic Light Pollution and Disrupting Marine Life*, NAT'L GEOGRAPHIC (Mar. 5, 2020), https://www.nationalgeographic.com/science/article/climate-change-arctic-light-pollution-marine-life [https://perma.cc/2CSC-BQF8]; NAT'L PARK SERV., *Sea Ice* (Jan. 25, 2022), https://www.nps.gov/subjects/aknatureandscience/seaice.htm [https://perma.cc/YQQ9-948C].

69. *See* Berge et al., *supra* note 12, at 2; Ludvigsen et al., *supra* note 33, at 1.

70. Eisner, *supra* note 65; Berge et al., *supra* note 12, at 1.

71. *See* Schultz, *supra* note 13.

72. *Id.*

73. *Id.*; *see also* LAURA KITCHIN GREENLEAF, ConserVING DARK SKIES AND NATURAL NIGHTSCAPES IN VIRGINIA 3, DARKSKY INT'L, https://www.dcr.virginia.gov/recreational-planning/document/vop-app-10-dark-skies.pdf [https://perma.cc/P7YJ-KTFD] (explaining that since the founding of the International DarkSky Association, "the 'dark skies movement' has expanded to encompass issues of environmental degradation, human health and safety, energy use and climate change, and community aesthetics").

adopted lighting ordinances.[74] Yet, a general dearth of public awareness and support for such policies results in little enthusiasm for enforcement.[75] A legal system favorable to resource exploitation creates obstacles to demonstrating the injury or harm to nature resulting from human activities necessary for remediation under these lighting regulations.[76]

Some states have enacted more fulsome legislation that sets valuable benchmarks for mitigating light pollution. As a leader in astronomical research, Arizona requires "all outdoor light fixtures" to be "fully or partially shielded" with exceptions for low-wattage fixtures, emergency lighting, and construction projects.[77] Outdoor lighting fixtures that do not meet these criteria must be extinguished between midnight and sunrise by an automatic shutoff device.[78] Similarly, New Mexico's Night Sky Protection Act requires all outdoor lighting fixtures to be shielded, with exceptions for low-wattage fixtures.[79] The statute also provides that no public or private outdoor facility shall be illuminated after 11:00 p.m., with some exceptions.[80] However, many other state light pollution restrictions are limited to outdoor lighting fixtures paid for with public funds, such as on the grounds of a state building or public road.[81]

While the existing state legislation signals a step in the right direction, the current landscape is inadequate, particularly for

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74. *Lighting Ordinances*, DARKSKY INT'L., https://darksky.org/resources/guides-and-how-tos/lighting-ordinances/ [https://perma.cc/E6ZX-8RQV].

75. *See* Barentine, *supra* note 7, at 30, 33 ("We face the ongoing general lack of awareness of light pollution as something that is known to harm nature, and therefore something to which nature has some inherent 'right' to remain free from.").

76. *Id.* at 30. Nuisance claims with respect to light pollution have also been largely ineffective as a tool for mitigating light pollution. *See* Lystrup, *supra* note 5, at 518 ("Unfortunately, given the relatively recent discovery of light pollution as harmful to human health and the environment, it is unlikely that light pollution will be accepted by attorneys general or district attorneys to advance public nuisance claims.").

77. ARIZ. REV. STAT. ANN. § 49-1102 (2023).

78. *Id.* § 49-1103.

79. N.M. STAT. ANN. §§ 74-12-1 to -2.

80. *Id.* § 74-12-5.

81. For a few examples of this limitation, see ARK. CODE ANN. § 8-14-104 (West 2023); COLO. REV. STAT. ANN. § 24-82-901 (West 2023); CONN. GEN. STAT. § 13a-110a (2023); DEL. CODE ANN. tit. 7, § 7101a (2023); VA. CODE ANN. § 2.2-1111 (West 2023); TEX. HEALTH & SAFETY CODE ANN. § 425.001 (2023).

coastal states and states with large bodies of navigable waters.[82] In fact, Texas is the only state that even defines "light pollution" within its statute.[83]

The presence of offshore energy in federal waters—particularly wind energy—is projected to grow rapidly. As a result, there will be sources of light pollution in waters not subject to existing state light pollution regulations.[84] Offshore energy production is already under way with two farms in federal waters, including a total of seven turbines.[85] Investment in clean energy is an important component of climate change response; however, these large-scale projects can emit a significant amount of light pollution.[86] There are important safety reasons for installing lights on wind turbines—particularly with respect to warning lights for air traffic visibility. However, wind farms can reduce ecosystem disturbances by integrating

82. Alaska, Washington, California, Massachusetts, New Jersey, Rhode Island, North Carolina, South Carolina, Georgia, Mississippi, Louisiana, and Hawaii are all states that have a coastline and do not have legislation to combat light pollution. *See* Schultz, *supra* note 13.

83. *See* TEX. HEALTH & SAFETY CODE ANN. § 425.001(2) (2023) ("'Light pollution' means the night sky glow caused by the scattering of artificial light in the atmosphere.").

84. *See Federal Offshore Lands*, BUREAU OF OCEAN ENERGY MGMT., https://www.boem.gov/oil-gas-energy/leasing/federal-offshore-lands [https://perma.cc/6AQL-A5MF]; *Ramping Up Renewable Energy*, Nat'l Oceanic & Atmospheric Admin., https://oceanservice.noaa.gov/economy/wind-energy/welcome.html [https://perma.cc/LAW9-MJDG].

85. *See Interior Department Approves Second Major Offshore Wind Project in U.S. Federal Waters*, U.S. DEP'T OF INTERIOR (Oct. 26, 2022), https://www.doi.gov/pressreleases/interior-department-approves-second-major-offshore-wind-project-us-federal-waters [https://perma.cc/PRU5-MGPX]; *Ramping Up Renewable Energy*, *supra* note 84 ("The U.S. government aims to deploy 30 [gigawatts] of wind energy production in federal waters by 2030.").

86. Sara Bjørn Aaen, Ivar Lyhne, David Philipp Rudolph, Helle Nedergaard Nielsen, Laura Tolnov Clausen & Julia Kirch Kirkegaard, *Do Demand-Based Obstruction Lights on Wind Turbines Increase Community Annoyance? Evidence from a Danish Case*, 192 RENEWABLE ENERGY 164, 172 (2022) ("[R]adar-based obstruction lights controlling system does indeed have a mitigation effect on annoyance levels."); *Nighttime Effects Light Pollution and Its Potential Health Impacts Near Wind Farms*, ENERGY 5 (Oct. 10, 2023), https://energy5.com/nighttime-effects-light-pollution-and-its-potential-health-impacts-near-wind-farms [https://perma.cc/5CPP-RV35]. For recent news cataloguing brightness from wind turbines, see Celia Llopis-Jepsen, *Wind Farms Are Transforming the Kansas Landscape. Here's an Effort to Tone Down Their Lights*, NPR (Mar. 1, 2023, 3:00 AM), https://www.kcur.org/news/2023-03-01/wind-farms-are-transforming-the-kansas-landscape-heres-an-effort-to-tone-down-their-lights [https://perma.cc/B6WM-5N7E]; Courtney Flatt, *Washington Bill Would Restrict Blinking Nighttime Lights on Wind Turbines*, OPB (Jan. 24, 2023, 9:00 AM), https://www.opb.org/article/2023/01/24/washington-bill-would-restrict-blinking-nighttime-lights-on-wind-turbines/ [https://perma.cc/Y2HE-KA2U]; Fred Khedouri, *Say Goodbye to the Milky Way*, VINEYARD GAZETTE (May 18, 2023, 3:05 PM), https://vineyardgazette.com/news/2023/05/18/say-goodbye-milky-way [https://perma.cc/9WZW-DEMD].

technology that illuminates the turbines only when aircraft are detected nearby.[87] For example, a handful of states have taken steps to mitigate light pollution from onshore wind turbines.[88] Because offshore energy is subject to permitting under the CWA, mechanisms exist to integrate compliance measures before potential rapid increases in offshore wind energy in the coming years.[89]

Wind energy is not the only offshore energy practice that invites excessive ALAN into the waters beneath it. Traditional offshore oil and gas platforms rely on leasing in federal waters in the Outer Continental Shelf (OCS) and the U.S. EEZ.[90] The EEZ falls under federal jurisdiction and therefore lies outside of the control of state light pollution measures.[91] Deep-water oil and gas operations emit a significant amount of artificial light, including electric light, gas flares, and illumination from vessel activity.[92] Large commercial vessels are subject to pollution restrictions under the CWA National Pollutant Discharge Elimination System (NPDES), which would allow the EPA to mitigate wasteful light pollution beyond what is necessary for navigation and the safety of workers onboard the vessel.[93] The CWA offers an opportunity to utilize an existing regulatory framework to encourage better lighting practices.

The current landscape of state laws and local ordinances primarily focuses on lighting restrictions related to nuisance and energy

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87. Windpower Engineering, *What Are the Lights on Top of a Wind Turbine?*, WINDPOWER ENG'G & DEV. (May 20, 2011), https://www.windpowerengineering.com/what-are-the-lights-on-top-of-a-wind-turbine/ [https://perma.cc/D5U7-8J5U].

88. WASH. REV. CODE ANN. § 70A.550.020 (2023) (requiring wind turbines to turn off warning lights if no aircraft is nearby); 42 Kan. Reg. 428-29 (2023) (requiring wind turbine lights to flash only when radar systems detect a nearby aircraft).

89. 33 U.S.C. § 1344.

90. *Federal Offshore Lands*, *supra* note 84.

91. *Id.*

92. *See* Erik E. Cordes, Daniel O. B. Jones, Thomas A. Schlacher, Diva J. Amon, Angelo F. Bernardino, Sandra Brooke, Robert Carney, Danielle M. DeLeo, Katherine M. Dunlop, Elva G. Escobar-Briones, Andrew R. Gates, Luciana Génio, Judith Gobin, Lea-Anne Henry, Santiago Herrera, Sarah Hoyt, Mandy Joye, Salit Kark, Nélia C. Mestre, Anna Metaxas, Simone Pfeifer, Kerry Sink, Andrew K. Sweetman & Ursula Witte, *Environmental Impacts of the Deep-Water Oil and Gas Industry: A Review to Guide Management Strategies*, 4 FRONTIERS ENV'T SCI. 1, 5-7 (2016).

93. *See* 40 C.F.R. § 122; *Commercial Vessel Discharge Standards: Frequently Asked Questions*, EPA, https://www.epa.gov/vessels-marinas-and-ports/commercial-vessel-discharge-standards-frequently-asked-questions [https://perma.cc/788E-BRZH]. For a deeper discussion of NPDES, see *infra* Part III.A.

savings. Yet, increasing energy development activities promise to bring a flood of unrestricted artificial light. Regulators should consider how lighting practices in offshore energy development threaten the chemical, physical, and biological integrity of water that the CWA endeavors to preserve.[94]

III. ARTIFICIAL LIGHT AT NIGHT AS A POLLUTANT UNDER THE CLEAN WATER ACT

The CWA provides valuable protections for waters of the United States, yet the current list of pollutants covered by the Act does not expressly encompass light pollution. Nevertheless, the purpose and language of the statute support the inclusion of light pollution from ALAN as a pollutant. This Part makes the case that the CWA already provides a regulatory framework to incorporate light pollution mitigation into the purview of the EPA.

A. How the Clean Water Act Supports Regulating Light Pollution

The CWA governs the discharge of pollutants into the waters of the United States and regulates water quality standards.[95] Today's CWA provides a structure for regulating discharges and authorizes the EPA to implement pollution control programs and national water quality criteria recommendations.[96] The NPDES program authorizes pollutant discharge into waters of the United States pursuant to certain limitations on what can be discharged and imposes monitoring and reporting requirements.[97] Because the CWA's jurisdiction includes the states' territorial seas, the Act provides a mechanism to protect those coastal waters from light pollution where state law is ineffective or nonexistent.[98]

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94. *See* 33 U.S.C. § 1251.

95. *Id.*; *Summary of the Clean Water Act*, EPA (June 22, 2023), https://www.epa.gov/laws-regulations/ summary-clean-water-act [https://perma.cc/AZT4-SH8Z].

96. 33 U.S.C. § 1251.

97. *See generally* 40 C.F.R. § 122 (2021); *NPDES Permit Basics*, EPA (Dec. 23, 2022), https://www.epa.gov/npdes/npdes-permit-basics [https://perma.cc/KNB4-4QP9].

98. *See* 33 U.S.C. § 1362(7).

Before the CWA, the Federal Water Pollution Control Act of 1948 was the first federal statute to address water quality.[99] Prior to 1948, water quality had been an issue exclusively of state and local concern.[100] By 1972, fears about water quality and a rise in an environmental public conscience led to an overhaul of the Federal Water Pollution Control Act, becoming the Clean Water Act we know today.[101] The 1972 version of the Act provided broader and more ambitious goals, aimed at the "restoration and maintenance of [the] chemical, physical, and biological integrity of [the] Nation's waters."[102]

Under the CWA, it is unlawful to discharge pollutants from a point source into navigable waters, defined as the "waters of the United States, including the territorial seas," without a permit.[103] The EPA enforces the CWA and implements pollution control programs, including setting wastewater standards for industry and national water quality criteria recommendations for pollutants in surface waters.[104] The CWA defines a point source as "any discernible, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged."[105] Because the Act clearly denotes that the list of point sources is not exhaustive, it does not preclude regulating point

99. *History of the Clean Water Act*, EPA (June 22, 2023), https://www.epa.gov/laws-regulations/history-clean-water-act [https://perma.cc/5SHE-YFMR].

100. *See id.*; CLAUDIA COPELAND, CONG. RSCH. SERV., RL30030, CLEAN WATER ACT: A SUMMARY OF THE LAW 2 (2016).

101. *See* COPELAND, *supra* note 100, at 2.

102. 33 U.S.C. § 1251(a).

103. *Id.* § 1362(7). As of this writing, "waters of the United States" (WOTUS) include five categories of waters: (1) traditional navigable waters, the territorial seas, and interstate waters; (2) impoundments of WOTUS; (3) tributaries of waters that are relatively permanent, standing, or continuously flowing bodies of water; (4) jurisdictional adjacent wetlands; and (5) other intrastate lakes and ponds, streams, or wetlands that meet the relatively permanent standard or the significant nexus standard. Revised Definition of "Waters of the United States"; Conforming, 88 Fed. Reg. 61964, 61965 (Sept. 8, 2023); *see also* Rapanos v. United States, 547 U.S. 715, 721 (2006) (challenging the jurisdiction of the EPA to regulate isolated wetlands under the CWA); Sackett v. EPA, 143 S. Ct. 1322 (2023) (invalidating parts of the January 2023 definition of WOTUS under the Supreme Court's interpretation of the CWA).

104. 33 U.S.C. § 1251.

105. *Id.* § 1362(14).

sources that fall outside of it.[106] In 2020, the Supreme Court expanded the scope of permitting requirements for discharges to include "the functional equivalent of a direct discharge from the point source into navigable waters."[107] Factors to consider when making this determination include:

> (1) transit time, (2) distance traveled, (3) the nature of the material through which the pollutant travels, (4) the extent to which the pollutant is diluted or chemically changed as it travels, (5) the amount of pollutant entering the navigable waters relative to the amount of the pollutant that leaves the point source, (6) the manner by or area in which the pollutant enters the navigable waters, (7) the degree to which the pollution (at that point) has maintained its specific identity. Time and distance will be the most important factors in most cases, but not necessarily every case.[108]

These factors, taken alongside the groundswell of emerging research, weigh in favor of finding that light-emitting fixtures conduct the functional equivalent of a direct discharge into a body of water. Certainly, the speed of light is incomprehensibly fast.[109] While the distance that light can travel varies greatly, the reach of both ambient and direct sources of light is broad and deep.[110] Research shows considerable quantities of light are capable of entering water bodies while maintaining harmful illuminating properties.[111] Given the permissiveness of the Act's definition of "point source," coupled with the Supreme Court's seven-factor test, ALAN stemming from light fixtures fits squarely within the understanding of "the functional equivalent of a direct discharge from [a] point source."[112]

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106. *See id.*

107. Cnty. of Maui v. Haw. Wildlife Fund, 140 S. Ct. 1462, 1468 (2020).

108. *Id.* at 1476-77.

109. *See How "Fast" Is the Speed of Light?*, NASA, https://www.grc.nasa.gov/www/k-12/Numbers/Math/Mathematical_Thinking/how_fast_is_the_speed.htm [https://perma.cc/E2QX-4XC8] ("Light travels at a constant, finite speed of 186,000 mi/sec.").

110. For a discussion of the nature and pervasiveness of light in water bodies, see *supra* Part II.

111. *See supra* Part II.

112. *Haw. Wildlife Fund*, 140 S. Ct. at 1468.

The CWA provides that discharge of a pollutant occurs when there is an "addition of any pollutant to navigable waters from any point source."[113] The Act does not explicitly define the word "discharge," however.[114] In the context of water, the Supreme Court articulated that the plain meaning of "discharge" refers to something "flowing or issuing out."[115] The Court also rejected the idea that an "addition" is fundamental to any discharge.[116] Rather, when activities lead to discharge that deteriorates the habitat for indigenous fish and other aquatic organisms, that discharge falls within the ambit of the CWA.[117] Within the context of thermal discharges, even though a traditional "pollutant" is not added to the water, a point source of thermal discharge is still required to comply with the effluent limitations of the CWA to meet water quality standards.[118] While light might not be "flowing" into a water body, it is "issuing" from a light source that is then entering that body of water. This would solicit a broad reading of discharge, but it is a reading that aligns with the purpose of the CWA: to protect the integrity of the nation's waters.[119]

Under the U.S. Code, the term "pollution" itself means "the man-made or man-induced alteration of the chemical, physical, biological, and radiological integrity of the water."[120] ALAN is both a man-made and a man-induced entity that has begun to alter the physical and biological integrity of the water by artificially illuminating marine ecosystems and disrupting the behaviors of aquatic organisms.[121] It is within the EPA's statutory authority to recognize a new pollutant if scientific research supports that it should be regulated

113. 33 U.S.C. § 1362(12).

114. *See generally id.* § 1362; S.D. Warren Co. v. Me. Bd. of Env't Prot., 547 U.S. 370, 375-76 (2006) (identifying the ordinary meaning of discharge to determine whether petitioner's dams resulted in a discharge triggering section 401 of the CWA).

115. *S.D. Warren*, 547 U.S. at 376.

116. *Id.* at 379 n.5; *see also* 33 U.S.C. § 1362(16).

117. *S.D. Warren*, 547 U.S. at 385.

118. *See id.* at 379. For a comparison of thermal pollution and light pollution, see *infra* Part III.B.

119. *See* John-Mark Stensvaag, *State Regulation of Nuclear Generating Plants Under the Clean Air Act Amendments of 1977*, 55 S. CAL. L. REV. 511, 535 n.131 (1982) (positing that a broad interpretation of "air pollution agent" under the Clean Air Act would allow the statute to cover nonionizing electromagnetic radiation, including visible light).

120. 33 U.S.C. § 1362(19).

121. Davies et al., *supra* note 6, at 352; Smyth et al., *supra* note 8, at 1.

under the CWA. Inclusion of a new pollutant is authorized by Congress in the CWA through petition to the EPA Administrator, the head of the agency.[122] To add a nonconventional pollutant, the Administrator must determine that "adequate test methods and sufficient data are available" to grant modifications with respect to the pollutant.[123] Thus, the EPA has jurisdiction to define ALAN as a pollutant and should do so.

Water quality standards govern the overall quality of a water body. These standards define "the water quality goals of a water body, or portion thereof, by designating the use or uses to be made of the water and by setting criteria that protect the designated uses."[124] Each state must then adopt water quality standards to protect public health or welfare, enhance the quality of water, and serve the purposes of the CWA.[125] The purposes of the Act direct that water quality standards should,

> wherever attainable, provide water quality for the protection and propagation of fish, shellfish and wildlife and for recreation in and on the water and take into consideration their use and value of public water supplies, propagation of fish, shellfish, and wildlife, recreation in and on the water, and agricultural, industrial, and other purposes including navigation.[126]

In determining criteria for water quality standards, the EPA is directed to use the "latest scientific knowledge" to identify the effects pollutants may have on plankton, fish, shellfish, wildlife, plant life, shorelines, beaches, esthetics, and recreation, and in doing so take into consideration "the effects of pollutants on biological community diversity, productivity, and stability."[127] The growing body of research on the identifiable effects from ALAN on the breeding, feeding, and predation of aquatic life would provide the EPA with a scientific basis to set water quality standards that

122. 33 U.S.C. § 1311(g)(4)(A).
123. *Id.* § 1311(g)(4)(B).
124. 40 C.F.R. § 131.2.
125. *Id.*
126. *Id.*
127. 33 U.S.C. § 1314(a)(1).

limit the amount of excessive ALAN entering the waters of the United States.[128]

B. Instructive Analogies: Thermal Discharges, Noise Pollution, and National Park Outdoor Lighting

Regulation of ALAN is likely to be met with criticism and reluctance to classify it as a true pollutant, consistent with historical treatment of other environmental harms, such as chemical fertilizer, pesticide, and herbicide—once considered too essential to restrict.[129] Yet, time and research revealed those chemicals to be hazardous to human health and wildlife.[130]

ALAN shares many common threads with other atypical pollutants currently regulated at the federal level. The analogies in this Section survey the EPA's treatment of non-conventional pollutants as well as the National Park Service's guidance on best lighting practices and mitigation of light pollution. This Section will demonstrate how the solutions proposed in this Note have already been successfully implemented with respect to other pollutants and could be effectively employed to curtail light pollution.

1. Heat Pollution and Thermal Discharges Under the Clean Water Act

Arguably the most instructive regulatory framework that could inform light pollution's integration into the CWA is the regulation of heat pollution and thermal discharges. The CWA includes heat within its definition of the word "pollutant" and regulates thermal discharges under its water quality standards by restricting outputs that cause changes to ambient water temperatures and dissolved oxygen levels.[131] Before thermal pollution was federally regulated,

128. *See* Berge, *supra* note 12, at 2 (finding that "fish and macrozooplankton communities exhibit an almost instantaneous response" from artificial light up to 200 meters deep); Ludvigsen et al., *supra* note 33, at 1 (explaining that certain aspects of the polar marine ecosystems are extremely sensitive to potential light pollution and traditional sampling techniques are insufficient to study them).

129. *See* Barentine, *supra* note 7, at 33.

130. *Id.*

131. 33 U.S.C. § 1313(g) (Heat standards: "Water quality standards relating to heat shall be consistent with the requirements of section 1326 of this title"); *id.* § 1313(h) (Thermal

it was regulated exclusively by the states.[132] However, a consensus about the threats of heat to the aquatic environment gave rise to heat's treatment as a pollutant.[133]

Thermal pollution primarily comes from fossil fuel and nuclear energy facilities discharging waste heat into water bodies to cool those facilities down.[134] Not coincidentally, regulation of thermal pollution arose following an exponential rise in demand for electricity—a water intensive industry—since the mid-twentieth century.[135]

The effects of thermal discharges captured the attention of both scientists and regulators because several aquatic species were highly sensitive to changes in temperature.[136] Higher temperatures can result in altered reproductive cycles, respiratory rates, metabolism, and other vital functions for fish and other types of marine life.[137]

Like other pollutants regulated by the CWA, heat and thermal discharges must be limited to assure the "protection and propagation of [a] balanced indigenous population [(BIP)] of shellfish, fish, and wildlife" in and on the body of water impacted by the discharge.[138] BIP refers to:

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water quality standards: "For the purposes of this chapter the term 'water quality standards' includes thermal water quality standards"); *id.* § 1362(6) (A pollutant under the CWA is currently defined as "dredged spoil, solid waste, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt and industrial, municipal, and agricultural waste discharged into water."); *see also* Region 1, EPA, *Merrimack Station (NH0001465) Response to Comments*, II-6 (May 22, 2020) [hereinafter *Merrimack Station*].

132. Frank E. Maloney, *More Heat Than Light: Thermal Pollution Versus Heat Energy Utilization*, 25 U. FLA. L. REV. 693, 697-99 (1973).

133. *Id.* at 693; *see also Hearings on Thermal Pollution Before the Subcomm. on Air and Water Pollution of the S. Comm. on Public Works*, 90th Cong. 600 (1968) ("I hope that the destruction of a part of our marine life is not the price we will have to pay for progress.").

134. Maloney, *supra* note 132, at 693.

135. *Id.* at 693 (citing FED. POWER COMM'N, REPORT ON PROBLEMS IN THE DISPOSAL OF WASTE HEAT FROM STEAM ELECTRIC PLANTS 7 (1969)); *see also* J. Samuel Walker, *Nuclear Power and the Environment: The Atomic Energy Commission and Thermal Pollution, 1965-1971*, 30 TECH. & CULTURE 964, 970 (1989).

136. Walker, *supra* note 135, at 970; *Hearings on Thermal Pollution*, *supra* note 133, at 713, 755, 932.

137. Walker, *supra* note 135, at 970.

138. 33 U.S.C. §§ 1313(d)(1)(B), (D), 1326(a).

> a biotic community typically characterized by diversity, the capacity to sustain itself through cyclic seasonal changes, presence of necessary food chain species and by a lack of domination by pollution tolerant species. Such a community may include historically non-native species introduced in connection with a program of wildlife management and species whose presence or abundance results from substantial, irreversible environmental modifications. Normally, however, such a community will not include species whose presence or abundance is attributable to the introduction of pollutants that will be eliminated by compliance by all sources with section 301(b)(2) of the Act; and may not include species whose presence or abundance is attributable to alternative effluent limitations imposed pursuant to section 316(a).[139]

In determining thermal discharge limits, the EPA assesses the protection and propagation of the BIP as well as any environmental stresses resulting from the discharge.[140] The "guiding principle" with respect to thermal discharges is that the limits of discharges are founded on technology-based and water quality-based standards, and that discharges do not affect the protection and propagation of the water body's BIP.[141]

Like heat and thermal discharges, light pollution inherently threatens the BIP of a given water body in comparable ways. The EPA defines thermal pollution as the "discharge of heated water from industrial processes that can kill or injure aquatic organisms."[142] Aquatic organisms that have adapted to a particular temperature range can be harmed or killed by an abrupt change in water temperature.[143] Effects of cold temperatures on aquatic life include lowered body temperatures, slowed growth and reproduction, and reduced ability to avoid more cold-tolerant predators.[144]

Because ALAN similarly disrupts predator-prey relationships, reproduction, and foraging behaviors, excess light may disturb the

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139. 40 C.F.R. § 125.71(c).

140. 33 U.S.C. § 1326(a).

141. *See Merrimack Station*, *supra* note 131.

142. *Glossary: T*, FED. REMEDIATION TECHS. ROUNDTABLE, https://www.frtr.gov/glossary/tterms.cfm [https://perma.cc/F26G-BPFP].

143. James E. A. John, *Thermal Pollution: A Potential Threat to Our Aquatic Environment*, 1 ENV'T AFFS. 287, 289 (1971).

144. *See id.* at 289-90.

presence of necessary food chain species in a similar manner to thermal pollution.[145] Both the increased intensity of artificial light as compared to moonlight and the broadening of spectrum of artificial light allow for predatory species to recognize their prey more easily and more often.[146] In turn, prey species could experience intensified predation pressure, resulting in population declines.[147] The pervasiveness of artificial light can also alter the types of species that are most populous, favoring those that are less visible under artificial night lighting and resulting in "domination by pollution tolerant species."[148]

Under the CWA, thermal discharges are subject to the "best available technology economically achievable" (BAT) standard, meaning that a site must implement the best available economically achievable performance of facilities in the industrial category or subcategory.[149] The Act provides that the EPA Administrator shall work with federal and state agencies and public and private organizations to conduct comprehensive studies of the "effects and methods of control of thermal discharge."[150]

Under a BAT standard, regulation under the CWA would require industrial and municipal sources of light pollution to impose technological improvements without compromising safety.[151] In fact, light pollution control measures may prove more economically viable with respect to energy costs.[152] There are several technologies that would improve safety and visibility while reducing the amount of light pollution permeating bodies of water. For example, full cutoff light fixtures direct light downwards, preventing the upward projection of light from the source.[153] The use of amber lighting,

145. *See* Berge, *supra* note 12, at 1; *supra* note 49 and accompanying text.

146. *See* Berge, *supra* note 12, at 1; *supra* note 49 and accompanying text.

147. *See* Davies et al., *supra* note 6, at 351.

148. *See* 40 C.F.R. § 125.71(c).

149. *See* 33 U.S.C. § 1311(b)(2)(A); *Learn About Effluent Guidelines*, EPA (Aug. 31, 2023), https://www.epa. gov/eg/learn-about-effluent-guidelines [https://perma.cc/7UWG-3Q65].

150. 33 U.S.C. § 1254(t).

151. *See* 33 U.S.C. § 1314(b)(1)-(2), (4).

152. *See Oil & Gas Lighting*, MCDONALD OBSERVATORY, https://mcdonaldobservatory.org/oil-gas-lighting [https://perma.cc/Q2HQ-6C53].

153. *See* MCDONALD OBSERVATORY, RECOMMENDED LIGHTING PRACTICES 5 (2021), https://mcdonaldobservatory.org/sites/default/files/pdfs/OG_LightingPractices_2mb.pdf [https://perma.cc/ZK63-PM6A] (last visited Feb. 7, 2024) ("[F]ull cutoff luminaires which are fully shielded ... [are] ... not emitting direct or indirect light above an imaginary horizontal plane

rather than blue-tinted lighting, is another method to effectively reduce the impact of light pollution as long as specific color lighting is not required for safety purposes.[154] For industrial sources of light pollution where light is not needed at night for safety purposes, lights should be on timers, dimmers, or motion sensors to reduce the amount wasted.[155]

2. The Noise Control Act and Clean Air Act Provisions

Noise pollution, defined as "unwanted or disturbing sound," is regulated by the Noise Control Act of 1972 (NCA) and the Clean Air Act (CAA).[156] Noise, like light, circumvents the traditional understanding of pollutants.[157] Noise pollution receives little attention likely because you cannot see, taste, or smell it.[158] However, Congress identified harms to human health and wellbeing that brought noise within the purview of the EPA.[159] The "major sources of noise" identified by Congress include "transportation vehicles and equipment, machinery, appliances, and other products in commerce."[160]

When issuing the NCA, Congress found "that, while primary responsibility for control of noise rests with State and local governments, Federal action is essential to deal with major noise sources in commerce control of which require national uniformity of treatment."[161] Congress's decision to regulate noise despite it being primarily a state-regulated area opens the door for a similar regulatory scheme for light pollution. When President Nixon signed the NCA into law, he said that the "most significant sources of noise"

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passing through the lowest part of the light source."); *see also Cut-off Angle (of a Luminaire)*, ILLUMINATING ENG'G SOC'Y, https://www.ies.org/definitions/cut-off-angle-of-a-luminaire/ [https://perma.cc/C2VB-FEY7].

154. *See* MCDONALD OBSERVATORY, *supra* note 153, at 7.

155. *See id.* at 8.

156. *See* 42 U.S.C. §§ 4901, 7641; *Clean Air Act Title IV—Noise Pollution*, EPA (Aug. 8, 2023), https://www.epa.gov/clean-air-act-overview/clean-air-act-title-iv-noise-pollution [https://perma.cc/KKK6-E2VA].

157. *See* Lystrup, *supra* note 5, at 520 ("Noise pollution is characteristically intangible and vague, as is light.").

158. *Clean Air Act Title IV—Noise Pollution*, *supra* note 156.

159. 42 U.S.C. § 7641(a); *Clean Air Act Title IV—Noise Pollution*, *supra* note 156.

160. 42 U.S.C. § 4901(a)(2).

161. *Id.* § 4901(a)(3).

involved interstate commerce and could only be regulated by federal government.[162] The Act provided that the EPA Administrator shall "investigat[e] ... the psychological and physiological effects of noise on humans and the effects of noise on domestic animals, wildlife, and property, ... with special emphasis on the nonauditory effects of noise."[163]

While the NCA was never repealed, noise is regulated by the CAA today.[164] In regulating noise, the CAA allows the EPA Administrator to determine how noise affects wildlife and people.[165] The EPA identified auditory and nonauditory effects of noise on animals, including physiological reactions in response to continuous noise, known as habituation.[166] Noise has also been found to induce reproductive changes and abnormal behaviors.[167] Particularly in aquatic ecosystems, acoustics inform organisms' distance receptors, and provide important information with respect to feeding, mating, and predation.[168]

Like noise, excessive ALAN leads to an unwanted or disturbing degree of brightness "that causes visual discomfort."[169] While neither noise nor light are tangible, they both have the capacity to disturb wildlife and ecosystem integrity. The negative effects of light and noise on aquatic organisms' essential functions are decidedly parallel: they both can impact feeding, reproductive habits, and predator-prey relationships.[170] Another factor considered in noise mitigation is projected growth of noise levels in urban areas.[171] Because coastal populations are predicted to double by 2060,[172] the

162. Lystrup, *supra* note 5, at 520.

163. 42 U.S.C. § 4913(b)(1).

164. *See EPA History: Noise and the Noise Control Act*, EPA (June 5, 2023), https://www.epa.gov/history/epa-history-noise-and-noise-control-act [https://perma.cc/6KR8-HEER].

165. 42 U.S.C. § 7641(a).

166. *See generally* EPA, EFFECTS OF NOISE ON WILDLIFE AND OTHER ANIMALS: REVIEW OF RESEARCH SINCE 1971 (1980).

167. *Id.* at 16, 18.

168. *Id.* at 42.

169. *See What Is Light Pollution?*, *supra* note 2; *see also Glare*, ILLUMINATING ENG'G SOC'Y, https://www.ies.org/definitions/glare/ [https://perma.cc/S385-PNQP] (defining "glare" as "[t]he sensation produced by luminances within the visual field that are sufficiently greater than the luminance to which the eyes are adapted to cause annoyance, discomfort, or loss in visual performance or visibility").

170. *See supra* Part I.B.

171. *See* 42 U.S.C. § 7641(a)(2)(B).

172. Davies et al., *supra* note 7, at 1.

potential exponential increase in light associated with this growth warrants investigation by the EPA to determine the best means of light abatement.

In deciding how to regulate light pollution, the EPA should consider the many ways light adversely impacts the ability of marine organisms to perform behaviors that support the subsistence of the water bodies they inhabit.

3. National Park Service Guidance on Artificial Lighting

The National Park Service (NPS) is a pioneer of light pollution mitigation at the federal level. The NPS defines light pollution on its website as "the introduction of artificial light, either directly or indirectly, into the natural environment," and recognizes it as a "mounting concern."[173] In fact, the NPS proclaims itself to be a "leader in the protection of dark night skies" and has measured night skies brightness levels in parks since 2001.[174] A 2016 study on light pollution, *The New World Atlas of Artificial Night Sky Brightness*, included the work of an NPS scientist along with efforts from the National Atmospheric and Oceanic Administration (NOAA).[175] Unsurprisingly, some of the highest concentrations of light pollution were found along coastlines.[176]

The NPS Organic Act sets forth the agency's mission to "conserve the scenery, natural and historic objects, and wild life in the System units and to provide for the enjoyment of the scenery, natural and historic objects, and wild life in such manner and by such means as will leave them unimpaired for the enjoyment of future

173. *Light Pollution*, NAT'L PARK SERV. (Sept. 4, 2020), https://www.nps.gov/subjects/nightskies/lightpollution.htm [https://perma.cc/V6YS-4U3S].

174. *New Study Shows Extent of Light Pollution Across the Night Sky*, NAT'L PARK SERV., https://www.nps.gov/subjects/nightskies/newworldatlas.htm [https://perma.cc/6TSN-GUP2]; *Night Sky Data Collection Sites*, NAT'L PARK SERV. (Feb. 21, 2023), https://www.nps.gov/subjects/nightskies/datacollectionsites.htm [https://perma.cc/MNR8-HP8P].

175. Fabio Falchi, Pierantonio Cinzano, Dan Duriscoe, Christopher C. M. Kyba, Christopher D. Elvidge, Kimberly Baugh, Boris A. Portnov, Nataliya A. Rybnikova & Riccardo Furgoni, *The New World Atlas of Artificial Night Sky Brightness* 2 SCI. ADVANCES 1, 1 (2016).

176. *See id.* at 2.

generations."[177] This includes the preservation of night skies and reduction of light pollution.[178]

Like the NPS, the EPA has a clear mission—"to protect human health and the environment," including air, land, and water.[179] In light of the body of research on the effects of ALAN, the EPA cannot properly serve its mission by leaving light pollution unchecked.[180] Moreover, the purpose of the CWA is specifically to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters."[181] With the rapid growth of ALAN in and near waters of the United States, mitigation of light pollution will soon become a critical component of maintaining the integrity of those waters.[182] The EPA should take cues from NPS guidance by recognizing the highly sensitive relationship between light and essential functions of aquatic organisms.

The NPS recognizes that "[m]any species rely on natural patterns of light and dark to cue behaviors."[183] It also acknowledges that ALAN can disrupt a "peaceful place" in the same way noise can, further evincing the parallels between noise and light discussed above.[184] With respect to the nighttime environment of the oceans, an NPS report on artificial night lighting identified ALAN as a threat to coral reefs, zooplankton, and planktivorous fishes because of the highly photosensitive properties of these organisms.[185] The NPS captures these considerations in its 2006 Management Policies, including a section on Lightscape Management.[186] There, the NPS articulates that "the absence of light in ... deep bodies of water influences biological processes and the evolution of species," offering the blind cave fish as an example of a highly light-sensitive aquatic

177. *See* 54 U.S.C. § 100101(a).

178. *See Night Skies*, NAT'L PARK SERV. (Mar. 15, 2023), https://www.nps.gov/articles/000/night-skies.htm [https://perma.cc/7GT9-BZV9].

179. *Our Mission and What We Do*, EPA (May 23, 2023), https://www.epa.gov/aboutepa/our-mission-and-what-we-do [https://perma.cc/4GEA-5ARB].

180. *See supra* Part I.B.

181. 33 U.S.C. § 1251(a).

182. *See id.*

183. *Protecting Natural Lightscape*, NAT'L PARK SERV. (Aug. 1, 2021), https://www.nps.gov/articles/natural-lightscape.htm [https://perma.cc/J45B-DJWN].

184. *See id.*

185. *See* LONGCORE & RICH, *supra* note 49, at 14.

186. NAT'L PARK SERV., MANAGEMENT POLICIES 2006 57 (2006), https://www.nps.gov/subjects/policy/upload/MP_2006.pdf [https://perma.cc/UU2P-7CCU].

organism.[187] In its lighting guidance, NPS considers how the light from stars, planets, and the moon influence humans and animals alike.[188] The Management Policies also suggest the restriction of artificial lighting to reduce the disruption of high-impact lighting on the physiological processes of living organisms.[189]

C. Regulation of Light Pollution Does Not Trigger the Major Questions Doctrine Following West Virginia v. EPA

The recent watershed Supreme Court case *West Virginia v. EPA* curtailed the EPA's regulatory reach with respect to greenhouse gases.[190] In that case, the Court considered whether Congress had authorized the EPA to issue a system of emission reduction through generation-shifting measures under section 111(d) of the CAA.[191] While the Court affirmed the EPA's authority to regulate carbon emissions under section 111(d), the Court found that the generation-shifting measures triggered the "major questions doctrine."[192]

The major questions doctrine requires administrative agencies to point to clear congressional authorization when they claim the power to make decisions of "vast economic and political significance."[193] Finding no authorization to alter the composition of the overall power system, the Court held that the EPA exceeded its authority intended by Congress when it issued the Clean Power Plan in such a way that would force a nationwide transition away from coal.[194] This holding applies in "extraordinary cases," where "'history and the breadth of the authority that [the agency] has asserted,' and the 'economic and political significance' of that assertion, provide a 'reason to hesitate before concluding that Congress' meant to confer such authority."[195]

187. *Id.*
188. *Id.*
189. *Id.*
190. *See* West Virginia v. EPA, 142 S. Ct. 2587, 2588 (2022).
191. *See id.* at 2607-08 ("Where the statute at issue is one that confers authority upon an administrative agency, that inquiry must be 'shaped, at least in some measure, by the nature of the question presented'—whether Congress in fact meant to confer the power the agency has asserted.").
192. *See id.* at 2609.
193. *See id.* at 2605.
194. *Id.* at 2616.
195. *Id.* at 2608.

Regulating light pollution under the CWA does not implicate the type of generation-shifting concerns found in *West Virginia*. First, like section 111(d) of the CAA, Congress authorizes the EPA within the CWA to implement pollution control programs and develop water quality standards.[196] Through this authorization, the EPA identifies pollutants and classes of pollutants to regulate, and in its development of guidelines, considers a wider range of pollutants than those included in the CWA, so long as research supports its inclusion, and regulation would further the goal of maintaining the integrity of the Nation's waters.[197] Second, the regulation of light pollution, as with any pollutant, is not in itself an action of vast political and economic significance. Instead, the introduction of guidelines and permitting requirements for ALAN mitigation is of little economic significance. Rather than introducing generation-shifting changes, these proposals are adaptive—they provide the opportunity for forthcoming technological progress and urbanization to proceed with fewer adverse impacts. Therefore, the regulation of light pollution under the CWA would not implicate the major questions doctrine as outlined in *West Virginia*.

CONCLUSION

Marine ecosystems are highly sensitive to subtle changes in light. These variations in light can inform many of their behaviors, from feeding to mating to migration. The mission of the CWA is to protect the integrity of the nation's waters. That integrity is threatened by the rapid expansion of coastal urbanization, the expected growth of offshore energy, and wasteful use of LED light in and near water bodies. This Note has addressed the growing scientific concerns regarding the harms of light pollution and the many ways the CWA provides a framework to regulate excess ALAN. Like noise or heat, light is difficult to see and quantify. Yet, the benefits of regulation span beyond the protection of aquatic ecosystems. Energy savings, cost reductions, and aesthetic benefits are all possible through the implementation of best lighting practices. Light is necessary and powerful, yet so ubiquitous that it is not widely considered as a

196. *See* 33 U.S.C. § 1252(a).
197. *See id.* §§ 1251(a), 1252.

harmful entity. The EPA has an opportunity under the CWA to protect marine environments from an ever-brighter civilization that is blind to the glaring threats of light pollution.

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