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HARVEST THE WIND, HARVEST YOUR DINNER: USING LAW TO ENCOURAGE AN OFFSHORE ENERGY-FOOD MULTIPLE- USE NEXUS

Robin Kundis Craig^{*}

ABSTRACT

Most scholars discuss the food-water-energy-climate nexus as it emerges on land. Less attention has been paid to the food-water-energy-climate nexus as it exists in the ocean, but that nexus exists—and it is beginning to be strained. This Article, a companion piece to the forthcoming “It’s Not Just an Offshore Wind Farm,” explores the international drive to combine offshore wind facilities with marine aquaculture, an emerging example of the water-energy-food nexus in the marine environment. Many nations are becoming increasingly interested in both offshore wind farms and open ocean marine aquaculture, but both enterprises take up considerable space in the marine environment. The resulting actual and potential crowding creates and threatens conflicts both with other uses, such as fishing, ecotourism, and shipping, and with marine protection and biodiversity goals. In Europe, where offshore wind facilities have become quite extensive, co-location of facilities has emerged as a strategy to reduce competition for offshore space that might simultaneously benefit marine aquaculture and enhance food security. This article examines the increasing drive toward co-locating offshore wind and open ocean aquaculture facilities and offers suggestions for how law might better promote this form of co-location through ongoing marine spatial planning efforts.

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I. INTRODUCTION: THE GROWING OFFSHORE NEXUS OF FOOD AND ENERGY

Most scholars discuss the food-water-energy-climate nexus as it emerges on land.¹ This terrestrial nexus generally coalesces around fresh water and includes the energy requirements for obtaining and delivering that water, the water demands of electricity generation, the water and energy needs of agriculture and the food distribution system, and the emerging effects of climate change on all of the above.² These issues can be complex, and new foci for discussion emerge regularly, such as the importance of conservation across the board,³ the potential for generating energy from food waste,⁴ and the links between this terrestrial nexus and human health.⁵

Less attention has been paid to the food-water-energy-climate nexus as it exists in the ocean. Nevertheless, this marine nexus exists, and it is beginning to show some strains.

¹ See generally, e.g., Roberta F. Mann, *Like Water for Energy: The Water-Energy Nexus through the Lens of Tax Policy*, 82 U. COLO. L. REV. 585 (Spring 2011); Ann E. Drobot, *Transitioning to a Sustainable Energy Economy: The Call for National Cooperative Watershed Planning*, 41 ENVTL. L. 707 (Summer 2011); Nathan Mee & Marc Miller, *Here Comes the Sun: Solar Power Parity with Fossil Fuels*, 36 WM. & MARY ENVTL. L. & POL'Y REV. 119, 135-36 (Fall 2011).

² See generally, e.g., Robin Kundis Craig, *Hydraulic Fracturing (Fracking), Federalism, and the Water-Energy Nexus*, 49 IDAHO L. REV. 241 (2013); Robin Kundis Craig, *Adapting Water Federalism to Climate Change Impacts: Energy Policy, Food Security, and the Water-Energy Nexus*, 5 ENVTL. & ENERGY L. & POL'Y J. 183 (Fall 2010); Robin Kundis Craig, *Water Supply, Climate Change, Desalination, and Energy Policy*, 22 PAC. MCGEORGE GLOBAL BUS. & DEV. L.J. 225 (2010). But see generally Rob C. de Loë & James J. Patterson, *Rethinking Water Governance: Moving Beyond Water-Centric Perspectives in a Connected and Changing World*, 47 NAT. RESOURCES J. 75 (Winter 2017) (challenging the water-centric perspective).

³ E.g., Carey W. King, Ashlynn S. Stillwell, Kelly M. Twomey & Michael E. Webber, *Coherence Between Water and Energy Policies*, 53 NAT. RESOURCES J. 117, 213 (Spring 2013).

⁴ E.g., Nicholas M. Vaz, Comment, *You Gonna Eat That? A New Wave of Mandatory Recycling Has Massachusetts and Other New England States Paving the Way Toward Feasible Food Waste Diversion and a New Player in Alternative Energy*, 26 VILL. ENVTL. L.J. 193 (2015).

⁵ E.g., Richard J. Gelting & Mansoor A. Baloch, *The food-water nexus: irrigation water quality, risks to food safety, and the need for a systems-based preventive approach*, 75 J. ENVTL. HEALTH 40 (2012).

Consider food, for example. Marine fisheries play a critical role in world food security, which generally refers to the state of having secure access to enough food for a given population at all times.⁶ Marine fish and shellfish have long been important sources of protein, particularly for coastal populations.⁷ According to the United Nations Food and Agriculture Organization (FAO), in 2013 “fish provided more than 3.1 billion people with almost 20 percent of their average per capita intake of animal protein,” and “fish contributes, or exceeds, 50 percent of total animal protein intake in some small island developing States, as well as in Bangladesh, Cambodia, Ghana, Indonesia, Sierra Leone and Sri Lanka.”⁸ Some developed nations also rely on marine fish for at least 20 percent of their protein, including Portugal, Norway, and Japan, as does China.⁹

However, overfishing has already limited the supply of wild ocean protein. As the FAO noted in its 2016 *State of World Fisheries Report* (reflecting 2014 data), capture of wild marine fish leveled off in the 1980s.¹⁰ Instead, marine aquaculture—the controlled and generally confined raising of marine plants, shellfish, and fish, usually for food, in ocean waters—has been growing substantially, especially in China.¹¹ Specifically, while wild capture of marine fish has been holding relatively steady at about 80 million tonnes per year, marine aquaculture production increased from 21.4 million tonnes per year in 2009 to 26.7 million tonnes per year in 2014.¹² This increase is generally attributed to three factors: the overall increase in human population and corresponding increase in demand for sources of protein; the plateauing of wild-caught marine fish and shellfish globally; and a desire to reduce the impacts from land-based agriculture, particularly meat production.¹³

⁶ World Health Organization, *Food Security*, <http://www.emro.who.int/nutrition/food-security/> (as viewed Nov. 29, 2017).

⁷ Marine Stewardship Council, *Fish as food*, <http://www.msc.org/healthy-oceans/the-oceans-today/fish-as-food> (as viewed Feb. 12, 2015).

⁸ UNITED NATIONS FOOD & AGRICULTURE ORGANIZATION, THE STATE OF WORLD FISHERIES AND AQUACULTURE: CONTRIBUTING TO FOOD SECURITY AND NUTRITION FOR ALL 71 (2016), available at <http://www.fao.org/3/a-i5555e.pdf> [hereinafter 2016 FAO SOFA REPORT].

⁹ *Id.* at 72-73, fig. 27.

¹⁰ *Id.* at 2, 3 fig. 1.

¹¹ *Id.* at 2.

¹² *Id.* at 4 tbl. 1.

¹³ Rebecca R. Gentry, Halley E. Froehlich, Dietmar Grimm, Peter Kareiva, Michael Parke, Michael Rust, Steven D. Gaines, & Benjamin S. Halpern, *Mapping the global potential for marine aquaculture*, 1 NATURE ECOLOGY & EVOLUTION 1317, 1317 (Sept. 2017). See also NOAA Fisheries, National Oceanic & Atmospheric Administration, *Aquaculture in the United States*, http://www.nmfs.noaa.gov/aquaculture/aquaculture_in_us.html (as viewed Nov. 1, 2017).

As one part of the marine food-water-energy-climate nexus, climate change and its “evil twin,” ocean acidification, pose new threats to marine sources of protein, both in terms of fishing and in terms of marine aquaculture.¹⁴ Warm air temperatures also warm the ocean, changing ocean currents, reducing dissolved oxygen content, and driving marine species toward the poles. The most immediate result is reduced fisheries in the tropics, but long-term effects could include mis-matched predator-prey relationships and crashed marine ecosystems.¹⁵ Ocean acidification inhibits shell formation in many marine species and has already been documented to be affecting both wild caught marine fisheries (such as Alaskan crab) and marine shellfish aquaculture.¹⁶

Another aspect of the marine nexus involves the effect of energy structures in marine waters on fish populations. Several studies, for example, have shown that offshore oil rigs can provide habitat for marine fish, perhaps contributing to the rebuilding of fish stocks.¹⁷ This connection is also recognized in law: In the United States, Section 388 of the Energy Policy Act of 2005¹⁸ gave the U.S. Department of the Interior—the U.S. Department that oversees offshore oil and gas leasing¹⁹—“jurisdiction over projects that make alternate use of existing oil and natural gas platforms in Federal waters,” including aquaculture.²⁰ According to the Bureau of Ocean Energy Management (BOEM), the

(“While the worldwide amount of wild-caught seafood has stayed the same year to year, there is a dramatic increase in the amount raised through aquaculture.”).

¹⁴ For a more thorough discussion of the effects of climate change on marine food supplies, see Robin Kundis Craig, *Re-Tooling Marine Food Supply Resilience in a Climate Change Era: Some Needed Reforms*, 38 SEATTLE U. L. REV. 1189, 1207-20 (Summer 2015).

¹⁵ *Id.* at 1207-14.

¹⁶ *Id.* at 1214-17.

¹⁷ For such studies regarding California’s offshore oil rigs, for example, see M.S. Love, et al., *Potential utility of offshore marine structures in rebuilding an overfished rockfish species, bocaccio* (*Sebastes paucispinis*), 104 FISH BULL. 383–390 (2006); M.S. Love, D.M. Schroeder, & W.H. Lenarz, *Distribution of bocaccio* (*Sebastes paucispinis*) and *cowcod* (*Sebastes levis*) around oil platforms and natural outcrops off California with implications for larval production, 77 BULL MAR SCI. 397–408 (2005); M.S. Love, J.E. Caselle, & L. Snook, *Fish assemblages around seven oil platforms in the Santa Barbara Channel*, 98 FISH BULL. 96–117 (2000).

¹⁸ Energy Policy Act of 2005, Pub. L. No. 109-58, § 388, 119 Stat. 594 (2005), (adding 43 U.S.C. § 1337(p)).

¹⁹ Outer Continental Shelf Lands Act (OCSLA), 43 U.S.C. §§ 1331-1356b (2012).

²⁰ Bureau of Ocean Energy Management, *Alternate Uses of Existing Oil and Gas Platforms*, <https://www.boem.gov/Renewable-Energy-Program/Renewable-Energy-Guide/Alternate-Uses-of-Existing-Oil-and-Gas-Platforms.aspx> (as viewed Nov. 4, 2017).

agency within Interior that implements this new provision, “Section 388 clarifies the Secretary of the Interior’s authority to allow an offshore oil and gas structure, previously permitted under the OCS Lands Act, to remain in place after oil and gas activities have ceased so that the structure can be used for other energy and marine-related activities. This authority provides opportunities to extend the life of facilities for non-oil and gas purposes, such as research, renewable energy production, and aquaculture, before being removed.”²¹

Offshore wind facilities also have a multiplicity of interactions with marine species and marine food production. Like oil rigs, offshore wind facilities appear to provide habitat for fish and other marine species.²² Moreover, “[c]urrently, offshore wind farms generally become exclusion zones for fishing,”²³ raising the possibility that they make good locations for marine protected areas.²⁴ However, to ease the political and economic difficulties the offshore wind facilities create for fishermen, researchers are also exploring the potential for at least certain kinds of commercial and recreational fishing to occur among the turbines.²⁵

The newest marine nexus between energy and food is the drive to use offshore wind farms as marine aquaculture facilities. Like marine aquaculture, world demand for offshore wind facilities is growing. However, both uses of the ocean can occupy

²¹ Bureau of Ocean Energy Management, *Alternate Uses of Existing Oil and Gas Platforms*, <https://www.boem.gov/Renewable-Energy-Program/Renewable-Energy-Guide/Alternate-Uses-of-Existing-Oil-and-Gas-Platforms.aspx> (as viewed Nov. 4, 2017).

²² M.C. Ashley, S.C. Magi, & L.D. Rodwell, *The potential for offshore windfarms to act as marine protected areas—A systematic review of current evidence*, 45 MARINE POLICY 301, 307-08 (2014).

²³ Katherine L. Yates, David S. Schoeman, & Carissa J. Klein, *Ocean zoning for conservation, fisheries and marine renewable energy: Assessing trade-offs and co-location opportunities*, 152 J. ENVTL. MANAGEMENT 201, 206 (2015).

²⁴ Ashley, Magi, and Rodwell, *supra* note 22, at 307-08; N. Christie, K. Smyth, R. Barnes, & M. Elliott, *Co-location of activities and designations: A means of solving or creating problems in marine spatial planning?*, 43 MARINE POLICY 254, 255-57 (2014).

²⁵ Tara Hooper & Melanie Austen, *The co-location of offshore windfarms and decapod fisheries in the UK: Constraints and opportunities*, 43 MARINE POLICY 295, 297-98 (2014); Yates, Schoeman, & Klein, *supra* note 23, at 205-07; V. Steizenmüller, R. Diekmann, F. Bastardie, T. Schulze, J. Berkenhagen, & Kloppe, G. Krause, B. Pogoda, B.H. Buck, & G. Kraus, *Co-location of passive gear fisheries in offshore wind farms in the German EEZ of the North Sea: A first socio-economic scoping*, 183 J. Envtl. Management 794, 800-04 (2016); Tara Hooper, Caroline Hattam, & Melanie Austen, *Recreational use of offshore wind farms: Experiences and opinions of sea anglers in the UK*, 78 MARINE POLICY 55, 69-60 (2017).

considerable space, sometimes in actual or potential conflict with still other marine activities, such as shipping or marine protected areas. Combining new offshore wind and marine aquaculture facilities can more efficiently preserve marine space for other activities while simultaneously promoting both renewable energy production, food security, and reduced pressures on wild fish stocks.

This Article, a companion piece to my *Public Land & Resources Law Review* article on the law governing offshore wind and open ocean marine aquaculture in the United States,²⁶ explores the international drive to co-locate offshore wind facilities with marine aquaculture. It begins in Part II with an overview of the emerging technologies for combining the two, including an examination of the growing demand for both uses of marine space. Part III then presents a case study regarding the actual deployment of co-located offshore wind/aquaculture facilities in Germany, the leader in this new endeavor. Part IV expands upon a suggestion from the *Public Land & Resource Law Review* article to provide a detailed argument of how marine spatial planning could be better deployed to facilitate increased use of combined offshore wind and aquaculture facilities around the world. The Article concludes that nations should actively shape their laws to encourage combined offshore wind farms/marine aquaculture facilities that promote the more environmentally benign forms of marine aquaculture, include shellfish, algae, and herbivorous and plankton-eating species of native fish.

II. THE EMERGING DRIVE TO CO-LOCATE MARINE AQUACULTURE AND OFFSHORE WIND

Both offshore wind and offshore aquaculture are industries that are growing quickly across the globe.²⁷ However, both industries require considerable offshore space, increasing the probability that they will interfere with other coastal activities, including marine commerce, fishing, recreation, and environmental protection.²⁸

Two primary technological solutions are available to reconcile the increasing desires for offshore wind and aquaculture with other demands on ocean space. First, companies can move marine aquaculture and offshore wind farms further out to sea, away from often intensely used immediate coastal waters. On the aquaculture side, “[o]pen ocean aquaculture is broadly defined as the rearing of marine organisms in exposed areas

²⁶ Robin Kundis Craig, *It's Not Just an Offshore Wind Farm: Combining Multiple Uses and Multiple Values on the Outer Continental Shelf*, XX PUBLIC LAND & RESOURCES L. REV. XXX (forthcoming Summer 2018).

²⁷ Christie et al., *supra* note 24, at 255.

²⁸ *Id.* at 254, 255.

beyond significant coastal influence.”²⁹ In the United States, for instance, as of 2010, only a few aquaculture research facilities had been sited in the federally-controlled waters (more than three miles out to sea³⁰) of the nation’s exclusive economic zone (EEZ, the first 200 nautical miles of ocean from shore³¹), and no commercial facilities had.³² Nevertheless, four commercial open ocean facilities were operating in state or territorial waters (the first three miles³³): Cates International’s moi (Pacific threadfin) facility and Kona Blue Water Farms’ kahala facility off Hawai’i; SnapperFarms’ cobia facility off Puerto Rico; and A.E. Lang Fisheries’ blue mussel facility off New Hampshire.³⁴ Moreover, open ocean aquaculture facilities are in operation or under development in Australia, Chile, China, France, Ireland, Italy, Japan, Mexico, and Norway.³⁵

As with marine aquaculture, countries initially tended to build offshore wind farms closer to shore, but the contemporary trend is to push them farther offshore, particularly in Europe. According to the Global Wind Energy Council, in 2015 and 2016, new European offshore wind farms were installed, on average, about 27 miles (43.5 kilometers in 2015, 43.3 kilometers in 2016) offshore.³⁶ In spring 2017, the Netherlands began building a 150-turbine wind farm 53 miles off the country’s northern coast, in the North Sea,³⁷ while in July 2017, Scotland began installing the world’s first floating (as opposed to anchored) offshore wind farm 15 miles off the coast.³⁸

²⁹ Harold H. Upton & Eugene F. Buck, Congressional Research Service, *Open Ocean Aquaculture* i (Aug. 9, 2010), available at <http://nationalaglawcenter.org/wp-content/uploads/assets/crs/RL32694.pdf>.

³⁰ *Compare* Submerged Lands Act, 43 U.S.C. §§ 1301(b), 1312 (2012) (establishing the seaward boundary of most states at three geographical miles) *with* Outer Continental Shelf Lands Act, 43 U.S.C. § 1331(a) (2012) (defining the outer continental shelf managed by the federal government as lying beyond this state boundary).

³¹ Exclusive Economic Zone of the United States of America, Pres. Proc. No. 5030, 78 Fed. Reg. 10,605 (Mar. 10, 1983).

³² Upton & Buck, *supra* note 29, at i.

³³ Submerged Lands Act, 43 U.S.C. §§ 1301(b), 1312 (2012).

³⁴ Upton & Buck, *supra* note 29, at i.

³⁵ *Id.* at 2.

³⁶ Global Wind Energy Council, GLOBAL WIND 2016 REPORT 59 (2016), available at <http://www.gwec.net/wp-content/uploads/2017/05/Global-Offshore-2016-and-Beyond.pdf>.

³⁷ Agence France-Presse, “Full tilt: giant offshore wind farm opens in North Sea,” *The Guardian*, <https://www.theguardian.com/environment/2017/may/09/full-tilt-giant-offshore-wind-farm-opens-in-north-sea> (8 May 2017).

³⁸ Roger Harrabin, “World’s first floating wind farm emerges off coast of Scotland,” *BBC News*, <http://www.bbc.com/news/business-40699979> (23 July 2017).

Second, companies can co-locate wind farms and marine aquaculture, transforming them into single facilities. After reviewing the global expansion of both offshore industries, this Part explores the advantages of co-location and the emerging technologies for using offshore wind facilities as aquaculture farms.

A. The Growth in Marine Aquaculture

As noted in the Introduction, marine aquaculture is growing quickly as an industry, largely in response to increasing consumer demands for seafood despite plateaued (and perhaps decreasing) wild catches. The number of marine species that can be grown through marine aquaculture is impressive: “About 600 aquatic species are now raised in captivity, with different species being preferred for different regions.”³⁹ In the United States, “marine aquaculture primarily produces oysters, clams, mussels, shrimp, and salmon as well as lesser amounts of cod, moi, yellowtail, barramundi, seabass, and seabream.”⁴⁰ However, aquacultured marine species are quite diverse and include abalone,⁴¹ Queen Conch,⁴² giant clam,⁴³ and, fairly recently, Bluefin tuna,⁴⁴ arguably the world’s most valuable and most endangered marine fish.

³⁹ World Ocean Review, *Aquaculture—protein provider for the world*, <http://worldoceanreview.com/en/wor-2/aquaculture/protein-provider-for-the-world/> (as viewed Nov. 5, 2017).

⁴⁰ NOAA Fisheries, National Oceanic & Atmospheric Administration, *What is aquaculture?*, http://www.nmfs.noaa.gov/aquaculture/what_is_aquaculture.html (as viewed Nov. 5, 2017).

⁴¹ Dept. of Animal Science, University of California, Davis, *California Abalone Aquaculture* (June 1996), available at <http://aqua.ucdavis.edu/DatabaseRoot/pdf/ASAQ-A10.PDF>; Eyre Peninsula, *Abalone (aquaculture)*, <http://seafoodfrontier.com.au/product/abalone-aquaculture/> (as viewed Nov. 5, 2017).

⁴² Caicos Conch Farm, *the World’s First and Only Commercial Conch Farm*, <http://www.caicosconchfarm.net/why-farm-turks-caicos-conch-and-fish.html> (as viewed Nov. 5, 2017).

⁴³ M. Mies, P. Dor, A. Z. Güth & P. Y. G. Sumida, *Production in Giant Clam Aquaculture: Trends and Challenges*, 25 REVIEWS IN FISHERIES SCIENCE & AQUACULTURE 286, 286-96 (2017).

⁴⁴ Dan Charles, “Farming The Bluefin Tuna, Tiger Of The Ocean, Is Not Without A Price,” *NPR Morning Edition*, <http://www.npr.org/sections/thesalt/2014/07/30/336339179/farming-the-bluefin-tuna-tiger-of-the-ocean-is-not-without-a-price> (July 30, 2014); Nancy Bazilchuk & Anne Sliper Midling, “Putting Bluefin tuna back on the menu—by farming them,” *Gemini*, <https://geminiresearchnews.com/2017/01/putting-bluefin-tuna-back-menu-farming/> (Jan. 20, 2017).

Much of the ocean is potentially available for aquaculture. Gentry et al. found in 2017 that over 11.4 million square kilometers of the ocean worldwide are at least potentially suitable for fish aquaculture, while over 1.5 million square kilometers could be used for shellfish aquaculture.⁴⁵ If all of this area were actually used, “approximately 15 billion tonnes of finfish could be grown every year—over 100 times the global seafood consumption.”⁴⁶ Of course, as the authors correctly noted, much of this area would eventually be excluded for other reasons—to protect “environmentally sensitive or high biodiversity areas, such as coral reefs”; because of physical and economic conflicts with other uses, such as ports or coastal infrastructure, military needs, or energy production; or because of “social interactions with wild fisheries, jobs, prices, and cultural heritage . . .”⁴⁷ Nevertheless, “[n]early every coastal country has high marine aquaculture potential and could meet its own domestic seafood demand, . . . typically using only a minute fraction of its of its ocean territory.”⁴⁸

There are growing imperatives to pursue deeper-water aquaculture,⁴⁹ but open ocean aquaculture also can have advantages for the industry. Specifically, “locating an aquaculture farm away from the nearshore area reduces the amount of anthropogenic factors that can influence the quality of the produce, *e.g.*, pollution, runoff, sewage, etc.”⁵⁰ Nevertheless, marine aquaculture can occupy considerable space. For example, some of the newest net pens (such as for raising salmon) encircle 91,000 cubic meters, well over three million cubic feet, of the water column and have a circumference of 240 meters (about 787 feet).⁵¹ Thus, finding ways to co-locate marine aquaculture with other marine facilities could be beneficial to preserving the coastal ocean as a multiple-use space.

B. The Growth in Offshore Wind

⁴⁵ Gentry et al., *supra* note 13, at 1318.

⁴⁶ *Id.*

⁴⁷ *Id.* at 1319.

⁴⁸ *Id.*

⁴⁹ Poul Holm, Bela H. Buck & Richard Langan, *Introduction: New Approaches to Sustainable Offshore Food Production and the Development of Offshore Platforms*, in BELA H. BUCK & RICHARD LANGAN, EDS., *AQUACULTURE PERSPECTIVE OF MULTI-USE SITES IN THE OPEN OCEAN: THE UNTAPPED POTENTIAL FOR MARINE RESOURCES IN THE ANTHROPOCENE 1*, 7-8 (SpringerOpen 2017); Nils Goseberg, Michael D. Chambers, Kevin Heasman, David Fredriksson, Arne Fredheim & Torsten Schlurmann, *Technological Approaches to Longline and Cage-Based Aquaculture in Open Ocean Environments*, in BUCK & LANGAN, *supra*, at 71, 72-73.

⁵⁰ Christie et al., *supra* note 24, at 257.

⁵¹ Huon Aquaculture, *Revolutionary New Net Pen Design*, <https://www.huonaqua.com.au/about/farm/new-pens/> (as viewed Nov. 5, 2017).

Like all wind-generated electricity, offshore wind facilities help to reduce greenhouse gas emissions. The relatively small Block Island Wind Farm off the coast of Rhode Island, for example, will purportedly “emit about 40,000 fewer tons of greenhouse gases per year than fossil fuels would to generate the same amount of energy. That’s the equivalent of taking 150,000 cars off the road.”⁵² In addition, offshore winds tend to be both stronger and more constant than terrestrial winds, often making offshore wind facilities a more reliable source of renewable energy than their terrestrial counterparts—and a source that can serve growing coastal populations and their energy demands.⁵³ Indeed, an October 2017 research article indicates that large deep water wind farms in the North Atlantic could produce several times the electricity of their terrestrial counterparts, based solely on the kinetic energy available.⁵⁴

For these and other reasons, worldwide investment in offshore wind is increasing. At the end of 2016, globally, there were “14,384 [megawatts] of installed offshore wind power capacity in 14 markets around the world.”⁵⁵ Broken down,

nearly 88% (12,631 [megawatts]) of all offshore wind installations were located in waters off the coast of ten European countries. The remaining 12% of the installed capacity is located largely in China, followed by Japan, South Korea and the United States.

The UK [United Kingdom] is the world’s largest offshore wind market and accounts for just under 36% of installed capacity, followed by Germany in the second spot with 29%. China passed Denmark in 2016 to achieve 3rd place in the global offshore rankings with 11%. Denmark now accounts for 8.8%, the Netherlands 7.8%, Belgium 5% and Sweden 1.4%. Other markets including Finland, Ireland, Spain, Japan, South Korea, the USA and Norway make the balance of the market.⁵⁶

⁵² Leanna Garfield, “America’s first offshore wind farm launched with GE turbines twice as tall as the Statue of Liberty,” *Business Insider*, <http://www.businessinsider.com/ge-wind-farm-block-island-2017-5?IR=T> (May 22, 2017).

⁵³ American Geosciences Institute, *What are the advantages and disadvantages of offshore wind farms?*, <https://www.americangeosciences.org/critical-issues/faq/what-are-advantages-and-disadvantages-offshore-wind-farms> (as viewed Nov. 5, 2017); G. Benassai, P. Mariani, C. Stenberg, & M. Christoffersen, *A Sustainability Index of potential co-location of offshore wind farms and open water aquaculture*, 95 *OCEAN & COASTAL Management* 213, 213 (2014).

⁵⁴ Anna Possner & Ken Caldeira, *Geophysical potential for wind energy over the open oceans*, 114 *PNAS* 11338, 11342 (Oct. 24, 2017).

⁵⁵ Global Wind Energy Council, *Offshore wind power*, <http://gwec.net/global-figures/global-offshore/> (as viewed Nov. 5, 2017).

⁵⁶ *Id.*

More and more countries are pursuing the development of offshore wind facilities,⁵⁷ and as of October 2017, at least 18 new wind farms were under construction, including seven in China and four each in the United Kingdom and Germany.⁵⁸ In addition, prices are dropping.⁵⁹ Indeed, in 2016 for the first time, in some locations offshore wind was cheaper than onshore wind.⁶⁰

Nevertheless, as is true with marine aquaculture, in terms of using ocean space, offshore wind facilities can be enormous, both vertically and laterally. In terms of height, when a blade points straight up, the largest offshore wind turbines can stretch 640 feet into the air.⁶¹ In terms of occupied surface area, as of June 2017, “[t]he largest offshore wind farm on Earth is the UK’s London Array, a massive site of 175 turbines in the outer Thames estuary.”⁶² It occupies 100 square kilometers (38.61 square miles) and uses nearly 450 kilometers (almost 280 miles) of cable.⁶³

Like other space-consuming activities in the ocean, offshore wind farms can lead to conflicts with other uses and values in the same ocean space. Identified potential conflicts include:

remote sensing or communications infrastructure such as radar, electromagnetic fields (EMF), signals, and beacons; recreation areas and tourist zones; community health and well-being; port facilities and traffic; airport facilities and traffic; overland transportation arteries; ocean shipping routes; commercial fishing; competing industrial or other uses for water and

⁵⁷ *Id.*

⁵⁸ Statista, *Number of offshore wind farm projects under construction as of October 2017, by country*, <https://www.statista.com/statistics/264258/number-of-offshore-wind-farms-under-construction-by-country/> (as viewed Nov. 5, 2017).

⁵⁹ Global Wind Energy Council, *Offshore wind power*, <http://gwec.net/global-figures/global-offshore/> (as viewed Nov. 5, 2017).

⁶⁰ *Id.* “In December 2016, the World Economic Forum reported that as the cost of producing wind turbines has fallen by more than 30% in the last three years, the cost of electricity from wind power has fallen to \$50 per megawatt hour on average worldwide, without subsidies. That’s half the cost of coal.” Chris Baraniuk, “The massive farms harnessing an invisible force,” *BBC*, <http://www.bbc.com/future/story/20170606-the-largest-wind-farms-in-the-world-are-in-the-uk> (6 June 2017).

⁶¹ Chris Baraniuk, “The massive farms harnessing an invisible force,” *BBC*, <http://www.bbc.com/future/story/20170606-the-largest-wind-farms-in-the-world-are-in-the-uk> (6 June 2017).

⁶² *Id.*

⁶³ London Array, *The Project*, <http://www.londonarray.com/the-project-3/> (as viewed Nov. 5, 2017).

the seabed, including mineral exploration; military use; cultural resources such as monuments and historic sites; visual resources; coastal infrastructure; ambient noise levels; terrestrial, coastal, and underwater flora and fauna; habitat areas including marine sanctuaries and critical habitat areas; air quality; water quality; meeting renewable energy goals; and protection of endangered species.⁶⁴

While many of these conflicts “are likely to be minor or could be eliminated or reduced through careful decision-making,”⁶⁵ resolving them nevertheless increases the regulatory burden on offshore wind farms. Again, as a result, finding ways to co-locate uses of marine space could benefit this growing source of renewable energy.

C. The Advantages of Co-Location

To begin with basic definitions, co-location refers most generally to putting two or more things or people in the same location to better accomplish some purpose. Thus, the *Merriam-Webster Dictionary* defines “colocation” to mean “to locate together; especially: to place (two or more units) close together so as to share common facilities.”⁶⁶ Co-location is a general strategy used in many industries, usually with the goal of increasing coordination and efficiency. In the human resources literature for business, for example, co-location of people working on the same project can improve project outcomes.⁶⁷

In the context of traditional energy and water facilities, co-location often involves physically locating two different kinds of facilities in close proximity so that one can make productive use of waste heat, wastewater, or other by-products of energy and water supply production from the other. For example, the Orange County Water District located

⁶⁴ Environmental Law Institute, *A Guide to State Management of Offshore Wind Energy in the Mid-Atlantic Region 9* (April 2013), available at <http://midatlanticocean.org/wp-content/uploads/2014/03/A-Guide-to-State-Management-of-Offshore-Wind-Energy-in-the-Mid-Atlantic-Region.pdf>.

⁶⁵ *Id.*

⁶⁶ Merriam-Webster Online, “colocate,” <https://www.merriam-webster.com/dictionary/colocate> (as viewed April 9, 2018).

⁶⁷ “Colocation is the concept of placing all the resources of a project team in a single physical location, so that the project can be completed in a good way. Colocated teams helps to improve communication, productivity, and team relationships. Colocation can be temporary for a certain important duration or for a longer or extended time or can be permanent.” Sopm Columbus, “Project Human Resource Management—Colocation for Better Project Outcomes,” *EduMind*, <http://www.edumind.com/management/blog/2015/03/colocation-in-project-management-for-better-project-outputs.html> (19 Mar. 2015).

its groundwater replenishment system next to the Orange County Sanitation District so that it could take the Sanitation District's treated wastewater and treat it still further, to drinking water quality.⁶⁸ Co-location here thus allows the Water District to intercept a waste stream that would otherwise be discharged into the Pacific Ocean and recycle it into water supply.⁶⁹ Similarly, seawater desalination plants that can co-locate with coastal power plants using once-through cooling can reduce both the economic and environmental costs of the desalination process.⁷⁰ The warmed seawater discharged from the power plant reduces the costs of desalination; the facilities can usually share a single intake and a single outfall structure, reducing costs and entrainment of marine organisms; and the excess return flow from the power plant can dilute the waste brine coming from the desalination plant.⁷¹ Both the Tampa Bay desalination plant in Florida⁷² and the new Carlsbad desalination plant near San Diego, California,⁷³ made use of this co-location strategy.

Co-location has also become important for terrestrial renewable energy, and there is considerable interest in co-locating wind and solar facilities to provide more continuous and dependable electricity. Because "wind power is traditionally best at night and solar power is only during the day, by combining their synergies, uncertainty is reduced and higher PPA's [Purchase Power Agreements] are possible."⁷⁴ In Australia, for example, the Australia Renewable Energy Agency has invested AU\$9.9 million in the 10-megawatt Gullen Solar Farm is being installed next to an existing 73-turbine wind facility, not only increasing the reliability of renewable electricity supply for Sydney but also saving about

⁶⁸ Orange County Water District, *Groundwater Replenishment System: Purification process*, <https://www.ocwd.com/gwrs/the-process/> (as viewed April 8, 2018).

⁶⁹ Orange County Water District, *GWRS—new water you can count on*, <https://www.ocwd.com/gwrs/> (as viewed April 8, 2018).

⁷⁰ Nikolay Voutchkov, "Power Plant Co-Location Reduces Desalination Costs, Environmental Impacts," *Industrial WaterWorld*, <http://www.waterworld.com/articles/iww/print/volume-7/issue-1/columns/product-focus/power-plant-co-location-reduces-desalination-costs-environmental-impacts.html> (Jan./Feb. 2007).

⁷¹ *Id.*

⁷² *Id.*

⁷³ Claude "Bud" Lewis Carlsbad Desalination Plant, *What We Do*, <http://www.carlsbaddesal.com/what-we-do.html> (as viewed April 8, 2018).

⁷⁴ Chris Pattison, "Co-location of Wind and Solar Power Plants and Their Integration onto the US Power Grid," North American Wind Energy Academy 2015 Symposium, Virginia Tech University (June 9-11, 2015), *available at* <https://vtechworks.lib.vt.edu/handle/10919/54690>. *See also* Ramteem Sioshani & Paul Denholm, *Benefits of Colocating Concentrating Solar Power and Wind*, 4:4 IEEE TRANSACTIONS ON SUSTAINABLE ENERGY 877, 877 (Oct. 2013) (calculating the potential benefits of co-locating wind and solar in Texas).

AU\$6 million—about 20 percent of the total project cost—in the costs of grid connections, site development, and governmental approvals.⁷⁵

As suggested above, the primary advantage of co-locating offshore wind and aquaculture facilities is to save space. As coastal nations' EEZs become more crowded, achieving multiple uses in many spaces will reduce conflicts—particularly when those uses, like wind and aquaculture, can demand considerable space.⁷⁶ So far, especially in the European context, aquaculture would be the primary beneficiary of co-location, because co-location could “reduce the high start-up costs associated with building an offshore facility, as well as providing some shelter in a high-energy environment”; indeed, in the North Sea, “without the turbine foundations to act as anchor points [for aquaculture infrastructure], due to the high energy environment of much of the North Sea, installation of mariculture equipment would not be economically feasible.”⁷⁷ While “establishing strong incentives for offshore wind developers” to co-locate is “more challenging,”⁷⁸ co-locating facilities may have other advantages, such as shared staff for maintenance, reduced overall numbers of maintenance trips, and common use of forecast and warning systems,⁷⁹ that aquaculture facilities might find valuable. Some researchers have also suggested that certain kinds of offshore aquaculture—such as growing macroalgae for biofuels—could become “a means of mitigating or offsetting environmental impacts of wind farm developments.”⁸⁰

⁷⁵ Ben Jervy, “Want to Improve Wind and Solar Power? Bring Them Together,” *Ensia*, <https://ensia.com/articles/renewable-energy-wind-solar/> (Nov. 7, 2016).

⁷⁶ For example, Germany's Federal Agency for Nature Conservation has emphasized the size of offshore wind facilities. Federal Agency for Natural Conservation, *Offshore Wind Power*, <https://www.bfn.de/en/activities/marine-nature-conservation/pressures-on-the-marine-environment/offshore-wind-power.html> (as viewed April 8, 2018). *See also* Christie et al., *supra* note 24, at 254-55, 257; Yates, Schoeman, & Klein, *supra* note 23, at 201; Benassai et al. *supra* note 53, at 213.

⁷⁷ Christie et al., *supra* note 24, at 257-58.

⁷⁸ *Id.* at 258.

⁷⁹ Erik Damgaard Christensen, Marian Stuiver, Raul Guanche, Flemming Møhlenberg, Jan-Joost Schouten, Ole Svenstrup Pedersen, Wei He, Barbara Zanuttigh, & Phoebe Koundouri, *Go offshore—Combining food and energy production 4* (Kgs. Lyngby: Technical University of Denmark. Department of Mechanical Engineering: 2015), *available at* http://orbit.dtu.dk/files/118776369/FINAL_Go_Offshore_Digital_version.pdf.

⁸⁰ Christie et al., *supra* note 24, at 258. Indeed, “macro-algae cultivation for sustainable biofuels” is becoming increasingly attractive “where offshore production negates the potentially damaging effects of converting agricultural land from food to fuel production.” *Id.* at 255.

D. Technologies for Co-Locating Offshore Wind and Marine Aquaculture Facilities

The potential for combining offshore wind and marine aquaculture facilities has been explored for several European countries in terms of both technology and law.⁸¹ Technologically, the idea usually has been to “combine offshore wind farm turbines as fixation point for aquaculture or to co-use an offshore wind farm site by installing aquaculture farms in between several wind turbines,” but in 2011 the European Commission called for even more complex multiple-use “offshore platforms that can combine various functions, such as aquaculture, wind and solar energy, and transport services within the same infrastructure. It is believed that this could offer significant benefits in terms of economics, optimizing spatial planning and minimizing the impact on the environment.”⁸²

To date, offshore energy facilities generally determine where co-located sites will occur:

The stability of offshore energy production structures (e.g. wind turbine and oil drilling platforms) is an attractive feature for a suite of requirements for aquaculture production, including attachment points for mooring cages and longlines, and for mounting feeding, hatchery and nursery systems. Though desirable attributes for energy and seafood production may not exist at all offshore sites, there is likely a subset of locations that are suitable, acceptable and economically viable.⁸³

So far, initial co-location projects in many countries have occurred with respect to offshore oil and gas platforms, not wind farms. For example, “The first synergy of offshore platforms with aquaculture was initiated in the Caspian Sea (27 km off the Turkmenian shore) in 1987, where a fish farm was moored next to an oil rig”⁸⁴

With respect to co-locating aquaculture at offshore wind facilities, “[o]ptions for aquaculture generally come in three categories: culture on simple structures such as ropes or frames (for example with seaweeds and molluscs), ranching/stock enhancement on the seabed involving wild release or simple cages (e.g., lobsters); or culture in intricate structures such as large cages or pens (for example fin fish).”⁸⁵ A variety of submerged

⁸¹ Lara Wever, Gesche Krause, & Bela H. Buck, *Lessons from stakeholder dialogues on marine aquaculture in offshore wind farms: Perceived potentials, constraints and research gaps*, 51 MARINE POLICY 251, 251, 254, 255 (2015).

⁸² *Id.*

⁸³ Holm, Buck & Langan, *supra* note 49, at 8.

⁸⁴ *Id.* (citation omitted).

⁸⁵ Christie et al., *supra* note 24, at 258.

cages for raising aquacultured fish, as well as submerged devices and support structures for growing shellfish and seaweed, have already been designed and developed.⁸⁶ The most common designs to date either independently anchor these cages and support structures to the seabed⁸⁷ or use an embedded wind turbine to support them.⁸⁸ However, companies are also experimenting with far more lightly anchored floating marine aquaculture facilities,⁸⁹ just like they are developing floating offshore wind turbines.⁹⁰

Planning technologies for offshore co-location are also being developed, often to be used in conjunction with marine spatial planning (discussed in Part IV). Such technologies include, for example, use optimization prioritization software, which allows planners to figure out how to optimize fishing, aquaculture, and marine protection while still meeting offshore renewable energy targets.⁹¹ Tests of this software indicate “that co-location could significantly reduce the cost of planning solutions, even at relatively low co-location levels” and “that co-location alters the location of priority areas for renewable energy sites”⁹² Sustainability Indices are another set of tools for determining the best “compromise” sites that produce optimum results for the combination of electricity

⁸⁶ Holm, Buck, and Langan, *supra* note 49, at 9 fig. 1.2; Bela H. Buck, Nancy Nevejan, Mathieu Wille, Michael D. Chambers & Thierry Chopin, *Offshore and Multi-Use Aquaculture with Extractive Species: Seaweeds and Bivalves*, in BUCK & LANGAN, *supra* note 40, at 23, 52 fig. 2.13.

⁸⁷ Holm, Buck, & Langan, *supra* note 49, at 9 fig. 1.2.

⁸⁸ Bela H. Buck, Gesche Krause, Bernadette Pogoda, Britta Grote, Lara Wever, Nils Goseberg, Maximilian F. Schupp, Arkadiusz Mochtak & Detlef Czybulka, *The German Case Study: Pioneer Projects of Aquaculture-Wind Farm Multi-Uses*, in BUCK & LANGAN, *supra* note 45, at 253, 258-59 fig. 11-2.

⁸⁹ E.g., Oscar M. Pérez, Trevor C. Telfer, & Lindsay G. Ross, *Geographical information systems-based models for offshore floating marine fish cage aquaculture site selection in Tenerife, Canary Islands*, 36:10 AQUACULTURE RESEARCH 946, 946-61 (July 2005), <https://doi.org/10.1111/j.1365-2109.2005.01282.x>.

⁹⁰ In October 2017, Statoil began operating the world’s first floating offshore wind facility 25 kilometers (15.5 miles) off the coast of Aberdeen, Scotland. Megan Geuss, “First floating wind farm, built by offshore oil company, delivers electricity,” *Ars Technica*, <https://arstechnica.com/science/2017/10/first-floating-wind-farm-built-by-offshore-oil-company-delivers-electricity/> (Oct. 18, 2017). For a more general overview of this technology, see Paul Slavounos, *Floating Offshore Wind Turbines*, 42:2 MARINE TECH. SOC. J. 39, 39-43 (Summer 2008).

⁹¹ Yates, Schoeman, & Klein, *supra* note 23, at 201-09.

⁹² *Id.* at 206-07.

generation and aquaculture production.⁹³ GIS modeling can also allow planners to test co-location scenarios at the planning stage before permitting actual facilities.⁹⁴

Nevertheless, much of the technical and technological competence to pursue co-located offshore wind and aquaculture facilities are still being developed and tested. For example, “Offshore structures will need to be modified or adapted to accommodate other uses without compromising functionality and safety,” and service vessels will need to be designed to accommodate multiple uses occurring among the turbines.⁹⁵ Sustainability Indices need additional biological and ecological information to improve their predictive accuracy.⁹⁶ Pilot projects and adaptive management are likely to be necessary before co-located facilities become the norm rather than the experiment.⁹⁷

III. PURSUING CO-LOCATED OFFSHORE WIND AND AQUACULTURE FACILITIES: THE EXAMPLE OF GERMANY

⁹³ See generally Benassai et al., *supra* note 53; Giacomo R. Di Tullio, Patrizio Mariani, Guido Benassai, Diane Di Luccio, & Luisa Grieco, *Sustainable use of marine resources through offshore wind and mussel farm co-location*, 367 ECOLOGICAL MODELING 34 (2018) (both discussing the use of Sustainability Indices to figure out where to co-locate offshore wind and shellfish aquaculture).

⁹⁴ See generally Antje Gimpel, Vanessa Stelzenmüller, Britta Grote, Bela H. Buck, Jens Floeter, Ismael Núñez-Riboni, Bernadette Pogoda, & Axel Temming, *A GIS modelling framework to evaluate marine spatial planning scenarios: Co-location of offshore wind farms and aquaculture in the German EEZ*, 55 MARINE POLICY 102 (2015).

⁹⁵ Holm, Buck, & Langan, *supra* note 49, at 13.

⁹⁶ Di Tullio et al., *supra* note 93, at 40.

⁹⁷ Christie et al., *supra* note 24, at 259.

The EEZs of European nations are quickly becoming some of most crowded stretches of ocean on the planet.⁹⁸ Much of this crowding can be attributed to the exponential growth in offshore wind facilities⁹⁹:

The first major offshore wind farms were Horns Rev 1 and Rødsand 1 in Danish waters with a capacity of 160 MW and 166 MW, respectively. Other countries initiated development in offshore wind and today, the UK has the largest installed capacity with a share of 56 per cent, followed by Denmark with 16 per cent, Germany with 13 per cent, and Belgium with 9 per cent.¹⁰⁰

In contrast, offshore aquaculture development in Europe has not been nearly so robust or widespread.¹⁰¹ Nevertheless, “The importance of aquaculture is stressed by the EC [European Commission] in policy documents such as the Blue Growth Strategy and the Strategic Guidelines for the sustainable development of EU aquaculture,”¹⁰² and recent studies also indicate that, while Europe’s North Sea nations are unlikely to follow

⁹⁸ “The North Sea is a crowded sea and development of offshore aquaculture intersects with other maritime activities, resulting in competing claims for marine space. This sets boundaries to the development of offshore aquaculture.” Henrice M. Jansen, Sander Van Den Burg, Bas Bolman, Robbert G. Jak, Pauline Kamermans, Marnix Poelman, & Marian Stuiver, *The feasibility of offshore aquaculture and its potential for multi-use in the North Sea*, 24 AQUACULTURE INTL. 735, 736 (2016); *accord*, Christie et al., *supra* note 24, at 254. As a Danish research team noted in 2015, “European oceans will be subject to massive development of marine infrastructure in the near future. The development includes energy facilities, e.g. offshore wind farms, exploitation of wave energy, and also development and implementation of marine aquaculture. This change of infrastructure makes the concept of multi-use offshore platforms particularly interesting.” Christensen et al., *supra* note 75, at 1. *See also* Di Tullio et al., *supra* note 93, at 34 (“Offshore wind farms are widely spread in Denmark, however, their growth has proven to limit the allowable space for aquaculture sites. Therefore the environmental authorities, to enhance sustainability, improve marine space utilization and reduce costs, are encouraging to move the aquaculture facilities between the wind farms.”).

⁹⁹ Gimpel et al., *supra* note 94, at 102; Di Tullio et al., *supra* note 93, at 34; Benassai et al., *supra* note 53, at 213.

¹⁰⁰ Christensen et al., *supra* note 79, at 2 (citation omitted).

¹⁰¹ “Marine aquaculture production is increasing in Europe—mostly due to salmon production in Norway. Other types of production are relatively stable or stagnating since the early 2000s. . . . In 2012, by far the most cultivated species in Europe was Atlantic salmon, followed by mussels, rainbow trout, European sea bass, gilthead sea bream, oysters and carps, barbel, and other cyprinids. Finfish production accounts for the increase in European aquaculture, while shellfish production has been slowly decreasing since 1999. Aquatic plants production has been emerging since 2007.” *Id.* at 3.

¹⁰² Jansen et al., *supra* note 98, at 736.

Norway in developing finfish aquaculture, shellfish aquaculture, especially mussels, could experience a resurgence and expansion in the near term, while aquaculture of marine plants could develop in the future.¹⁰³ To fit expanded mussel aquaculture into the North Sea, however, co-location with offshore wind facilities is like to be necessary.¹⁰⁴

Within Europe, Germany already has one of the most crowded EEZs in the North Sea (see Figure 1). Nevertheless, although Germany is one of the world leaders in offshore wind farms, it lags behind other countries in developing offshore aquaculture.¹⁰⁵ Even so, Germany is clearly a world leader in pursuing co-location of offshore wind farms and other marine uses, including marine aquaculture.¹⁰⁶

¹⁰³ *Id.* at 735, 737-40.

¹⁰⁴ *Id.* at 741.

¹⁰⁵ Indeed, Germany “can be counted with the few developing nations that have not adopted any form of aquaculture. The reasons for this stagnation are mainly as follows: Conflicts exist between interested parties on coastal land management issues. Such parties include commercial and pleasure boat traffic, gravel mining, marine and local fishing coops, and protected areas, such as national parks. Problems with regulation and assignment of areas in the North Sea and its near-shore waters arose due to these conflicts. In addition, complex local hydrodynamic conditions such as large wave heights and strong water currents have hindered the aquaculture development in Germany.” Buck et al., *The German Case Study*, *supra* note 88, at 257.

¹⁰⁶ Thus:

In Germany, the plans for the massive expansion of wind farms in offshore areas of the North Sea triggered the idea of a combination of wind turbines with other uses. Various multi-use concepts were followed led by tourism, marine protected areas (MPAs), passive fishery actions as well as desalination and research, just to name a few. Another concept is to co-use wind farm installations with extensive aquaculture of native bivalves and macroalgae. Due to the fact that offshore wind farms provide an appropriately sized area free of commercial shipping traffic (as most offshore wind farms are designed as restricted-access areas due to hazard mitigation concerns), projects on open ocean aquaculture have been carried out since 2000 in the German Bight. Further expansion towards finfish culture has since then been proposed and carried out in land-based facilities with regard to system design and coupling technologies for submersible fish cages as well as Integrated Multi-trophic Aquaculture (IMTA) and site-selection.

Holm, Buck & Langan, *supra* note 49, at 11. See also Vanessa Stelzenmüller, A. Gimpel, M. Gopnik, & K. Gee, *Aquaculture Site-Selection and Marine Spatial Planning: The Roles of GIS-Based Tools and Models*, in BUCK & LANGAN, *supra* note 49, at 131, 138 (“In the southern North Sea and GeBight, the potential co-location of offshore wind and aquaculture has gained momentum due to the allocation of large areas for offshore wind,

Figure 1: Human Uses and Protected Sites in Germany's EEZ

SOURCE: <https://www.bfn.de/fileadmin/BfN/meeresundkuestenschutz/Bilder/Karten-Grafiken/Offshore-en-Windkraftprojekte-Nordsee-sowie-Kabelanbindungen-en.jpg>

Offshore Wind Farms, Grid Connections and Natura 2000 Sites in the German Exclusive Economic Zone (EEZ) of the North Sea

Designed by: Federal Agency for Nature Conservation (BfN), Marine and Coastal Conservation Unit, As of: 01.03.2015

Progress by many measures has been slow. As of 2015, for example, “all attempts to move bivalve aquaculture off the coast to a more hostile environment within wind farm areas are on a pilot scale.”¹⁰⁷ Nevertheless, by that year “[a] number of projects [we]re

including approximately 35% of the German EEZ of the North Sea, and the resulting loss of space for other sectors, such as fisheries . . .”).

¹⁰⁷ Wever, Krause, & Buck, *supra* note 81, at 251.

underway to test the feasibility of offshore farming in the Exclusive Economic Zone (EEZ) of the German Bight, such as the ongoing project Offshore-Site-Selection (OSS). Here, wind farm planners as well as representatives of fisheries, economics and science are together suggesting future sites with best conditions for the cultivation of various aquaculture species.”¹⁰⁸ Several species have been investigated for their potential use in co-located facilities,¹⁰⁹ as have several technologies.¹¹⁰

The German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety initiated the Open Ocean Multi-Use project to more specifically investigate the technical and social possibilities for combining wind farms and aquaculture in Germany’s EEZ.¹¹¹ As is true in much of the European Union, however, the aquaculture component suffers from both lack of legislation and lack of social acceptance.¹¹² Socially, in Germany, the tensions between the offshore wind industry and fishers can be considerable: “The offshore wind energy sector has turned into a powerful, international player that has benefitted immensely from the current political agenda in Germany. Other users, such as fisheries, are pushed out of large areas of the ocean.”¹¹³ Moreover, while “[m]any stakeholders that were consulted believe that the combination of a limited number of sustainable marine uses—such as offshore wind energy and fish farming—appears as an attractive solution to increasing, and competing demands for limited ocean space,” “when it comes to the details of a hypothetical co-management scenario highly controversial attitudes, perceptions, concerns, and interests surface. Of overriding concern to many of the stakeholders are potentially harmful impacts of offshore aquaculture systems to the marine environment.”¹¹⁴

Offshore co-location goals in Germany, as in many countries, could benefit from improvements in the law. Currently, offshore co-located facilities are subject to a complex mix of international, EU, and German laws that are nevertheless incomplete,¹¹⁵ particularly with respect to aquaculture: Germany has “a highly comprehensive regulatory framework for offshore wind energy, but only a weak and uncertain framework for offshore aquaculture installations is in place. For the latter, technological as well as ecological standards are yet needed.”¹¹⁶

¹⁰⁸ *Id.*

¹⁰⁹ Buck et al., *The German Case Study*, *supra* note 88, at 260-88; Gimpel et al., *supra* note 94, at 106 tbl. 1, 110-14.

¹¹⁰ Buck et al., *The German Case Study*, *supra* note 88, at 288-322.

¹¹¹ Wever, Krause, & Buck, *supra* note 81, at 251-52.

¹¹² Holm, Buck & Langan, *supra* note 49, at 2.

¹¹³ Buck et al., *The German Case Study*, *supra* note 88, at 322.

¹¹⁴ *Id.* at 323.

¹¹⁵ *Id.* at 340-42.

¹¹⁶ *Id.* at 342.

The net result for Germany is that offshore aquaculture may never become a commercial reality. As one group of researchers summarized,

the current gap between oceans as commons and ocean as private property as well as diverging views and pictures leads to a contested sea space. A more holistic, integrated approach to ocean management that acknowledges the interconnectedness of human and natural systems is timely. However, there is a high risk of failing in the current window-of-opportunity to integrate open ocean aquaculture within the emerging management of the marine realm. What is at odds is the management discourse of the politically powerful vs. newcomers, reaffirming the socially constructed nature of knowledge.¹¹⁷

Thus, offshore aquaculture, as the “new kid on the block,” lacks both physical space to operate in the North Sea and a social-legal framework to support its development and integration into existing marine uses. A more regulatory version of marine spatial planning could help Germany and other nations that have aggressively pursued offshore wind development to integrate co-located aquaculture into their marine spaces.

IV. EXPANDING THE REGULATORY USE OF MARINE SPATIAL PLANNING TO PROMOTE CO-LOCATED OFFSHORE WIND/AQUACULTURE FACILITIES

As events in Germany suggest, the pursuit of multiple use policies for marine space necessarily involves multiple stakeholders. “Balancing the needs and interests of multiple stakeholders lies at the heart of policymaking; this holds especially true in areas where spatial claims clash with increasingly scarce resources and space, such as in coastal zones and increasingly also marine space.”¹¹⁸ Marine spatial planning provides one widely recognized method both for addressing stakeholders’ interests and rationalizing the siting and regulation of co-located offshore wind and marine aquaculture facilities.¹¹⁹

The concept of marine spatial planning derives from a terrestrial counterpart: land use planning and municipal zoning. The marine concepts are similar, as Tundi Agardy has explained:

¹¹⁷ *Id.* at 342-43.

¹¹⁸ Wever, Krause, & Buck, *supra* note 81, at 258.

¹¹⁹ A number of marine co-location studies explicitly identify marine spatial planning as *the* planning and legal tool for both promoting and most productively addressing whether and where co-location of offshore wind facilities and open ocean aquaculture will be possible, including: Christie et al., *supra* note 24, at 254-55; Yates et al., *supra* note 23, at 201-02, 206-08; Gimpel et al., *supra* note 94, at 102; Di Tullio et al., *supra* note 93, at 35.

Zoning is a set of regulatory measures used to implement marine spatial plans—akin to land use plans—the specify allowable uses in all areas of the target ecosystem(s). Different zones accommodate different uses, or different levels of use. As in municipal zoning, regulations address prohibitions or permitted uses, or both. All zoning plans are portrayed on maps, since the regulations are always area-based.¹²⁰

Nevertheless, unlike most land use planning, marine spatial planning seeks from the beginning to account for the health of the relevant marine ecosystems and to achieve ecosystem-based management in the oceans, balancing biodiversity protection with human use.¹²¹

Marine spatial planning has broad support among coastal nations, particularly developed coastal nations. Australia, for example, has long been a leader in marine spatial planning for the Great Barrier Reef;¹²² a European Union directive encourages marine spatial planning¹²³ and the European Commission has published strategic guidelines to encourage the siting of aquaculture¹²⁴; and the United States is pursuing regional marine spatial planning in response an Executive Order that President Obama issued.¹²⁵

Even so, marine spatial planning is an inherently flexible tool, and “[d]ifferent ideas about how to implement MSP have also emerged. Some marine spatial plans (e.g., in the United Kingdom) favor a broad, strategic approach that sets out general guidelines for the use of sea areas, while others (e.g., in Germany) are based on more detailed zoning, creating areas that favor a particular use and other areas where certain uses are prohibited”¹²⁶ (see Figure 2). Notably, moreover, “[t]he rapid expansion of the marine renewable energy industry, driven by nations’ commitments to reducing greenhouse gas emissions, has been a catalyst for the progression of ocean zoning and marine spatial planning.”¹²⁷

¹²⁰ TUNDI AGARDY, OCEAN ZONING: MAKING MARINE MANAGEMENT MORE EFFECTIVE 6 (2010).

¹²¹ INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION & MAN AND THE BIOSPHERE PROGRAMME, UNESCO, MARINE SPATIAL PLANNING: A STEP-BY-STEP APPROACH TOWARD ECOSYSTEM-BASED MANAGEMENT 10 (2009).

¹²² ROBIN KUNDIS CRAIG, COMPARATIVE OCEAN GOVERNANCE: PLACE-BASED PROTECTIONS IN AN ERA OF CLIMATE CHANGE 139-46 (Edward Elgar 2012).

¹²³ Stelzenmüller et al., *supra* note 109, at 132.

¹²⁴ *Id.* at 133.

¹²⁵ For a more detailed account of marine spatial planning in the United States, see Craig, *It's Not Just an Offshore Wind Farm*, *supra* note 26, at xx-xx.

¹²⁶ Stelzenmüller et al., *supra* note 106, at 132-33.

¹²⁷ Yates, Schoeman, & Klein, *supra* note 23, at 201.

Figure 2: Germany's Marine Spatial Plan for Its EEZSOURCE: <http://msp-platform.eu/practices/maritime-spatial-plan-german-eez-north-sea>

As other have noted, marine spatial planning “brings a more coordinated approach to overall sea use, promising greater accountability and transparency of decision-making by including a wide range of stakeholders from all sectors. It may also increase the effectiveness of investments, reduce duplication of effort, and speed up decision-making”¹²⁸ As such, well-designed marine spatial planning can provide a transparent process for involving all stakeholders and explicitly identifying and resolving conflicts and tradeoffs among marine uses.

Done well, marine spatial planning also provides the governments of coastal nations with a wealth of substantive information that can then be directly tied to improved regulation designed to encourage ecologically respectful economic development of a nation’s EEZ. Specifically, marine spatial planning generally allows governments to: (1) identify ocean areas of use, including the kinds of uses made, the number of uses made, and the intensity of those uses; (2) identify ecologically sensitive areas where some or all human use should be prohibited; and (3) identify mutually compatible uses.

Researchers have already suggested that the marine spatial planning process can and should be tied to policies and regulations that encourage marine aquaculture. “For

¹²⁸ Stelzenmüller et al., *supra* note 106, at 133 (citations omitted).

example, designating appropriate aquaculture areas and then linking these areas to streamlined licensing procedures could render development less uncertain and increase investor interest As a strategic tool, [marine spatial planning] can allocate space for aquaculture at sites with both favorable operational characteristics (economic and ecological) as well as lower potential for conflict with other sectors”¹²⁹

Expanding beyond single uses, moreover, one of the functions of marine spatial planning is often to identify areas where uses can successfully co-locate. In the United States, for example, the State of Washington concluded in its new (2017) marine spatial plan that existing uses—including many economically important marine aquaculture facilities—would limit the development of offshore wind in the state’s marine waters.¹³⁰ However, in places—like Europe—where offshore wind developed first, marine spatial planning “would also allow for more structured consideration of co-location of different uses, such as aquaculture taking place around offshore wind structures, providing both a venue for the respective stakeholders to come together and a greater incentive for investment.”¹³¹ Thus:

Both English and German marine plans encourage the combination of aquaculture with other uses. In the UK, a strong national policy statement calls for consideration of the “significant opportunities for co-existence of aquaculture and other marine activities” The UK’s East Inshore and Offshore Marine Plans also stipulate that co-location opportunities should be maximized wherever possible, and that “proposals for using marine areas should demonstrate the extent to which they will co-exist with other existing or authorized activities and how this will be achieved”¹³²

In addition, in coordinating marine spatial planning and offshore regulation, coastal governments could give regulatory preference to the more environmentally benign forms of marine aquaculture—aquaculture of algae, which like all plants absorbs carbon dioxide and produces oxygen and which can be processed into biofuels as well as food; shellfish, which are filter feeders requiring little care, and which can actually improve water quality; and native species of herbivorous or plankton-eating fish, which do not decimate other marine fish populations through their food demands and do not risk invasive species problems if escape occurs.

¹²⁹ *Id.* at 134 (citations omitted).

¹³⁰ WASHINGTON DEPARTMENT OF ECOLOGY, WASHINGTON DEPARTMENT OF FISH & WILDLIFE, & WASHINGTON DEPARTMENT OF NATURAL RESOURCES, DRAFT MARINE SPATIAL PLAN FOR WASHINGTON’S PACIFIC COAST 4-25 (Oct. 2017), *available at* http://www.msp.wa.gov/wp-content/uploads/2017/draft_MSP_and_appendices.pdf.

¹³¹ Stelzenmüller et al., *supra* note 106, at 134.

¹³² *Id.* at 136-37 (citations omitted).

V. CONCLUSION

Our hungry world increasingly relies on offshore aquaculture for its food supply, at the same time that climate change mitigation goals help to propel the development of offshore wind facilities, at the same time that biodiversity goals and increased recognition of the damage we are doing to the ocean encourages the establishment of more and bigger marine protected areas. The parts of the ocean subject to national jurisdiction are becoming crowded, and the crowding is breeding increasing conflict.

Co-location of offshore wind facilities with the more environmentally friendly forms of offshore aquaculture is one way to pursue these three goals simultaneously. In nations, like many in Europe, that have pursued offshore wind development first, the infrastructure to support deeper water aquaculture already exists; as such, the focus should be on developing laws and procedures to encourage the right kinds of co-located aquaculture. In contrast, in nations like the United States that are just now starting to develop offshore wind facilities, legal development might take a more comprehensive approach from the beginning, providing additional incentives to wind facility developers that are willing to tolerate aquaculture operations within their facilities. At the same time, the United States could also be developing more robust policies to encourage active aquaculture at decommissioned oil and gas platforms, developing technical expertise in deeper water and open ocean aquaculture while making extended use of existing structures that already take up space in the marine environment.

All of these developments, however, would benefit from more robust legal ties between marine spatial planning and regulation of these facilities. Done correctly, marine spatial planning can allow for coherent and coordinated development of marine space so that uses that need to be separated are kept apart, uses that can be co-located are encouraged to do so, and the marine environment itself remains protected. Separate and individually complex permitting requirements for both offshore wind and marine aquaculture do not encourage companies to think in terms of co-location; instead, a comprehensive marine spatial planning process situated within a corresponding legal framework could act to streamline permitting requirements for desirable facilities co-locating in identified preferred locations. The marine water-energy-food-climate nexus is upon us, and proactive multiple-use planning and regulation will make for a more productive and resilient future than uncoordinated marine crowding.