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Response from ENGOs to Request for Information â€“ Entangled Debris Monitoring for Floating Offshore Wind Infrastructure

The Natural Resources Defense Council, Center for Biological Diversity, California Coastal Protection Network, Environmental Defense Center, Monterey Bay Aquarium, National Audubon Society, and Surfrider Foundation, respectfully submit the attached comments to the California Energy Commissionâ€™s (CEC) Request for Information on Entangled Debris Monitoring for Floating Offshore Wind Infrastructure.

Additional submitted attachment is included below.

California Energy Commission
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September 13, 2024

Response from Environmental NGOs to Request for Information – Entangled Debris Monitoring for Floating Offshore Wind Infrastructure

On behalf of the Natural Resources Defense Council, Center for Biological Diversity, California Coastal Protection Network, Environmental Defense Center, Monterey Bay Aquarium, National Audubon Society, and Surfrider Foundation, we submit these comments to the California Energy Commission's (CEC) *Request for Information on Entangled Debris Monitoring for Floating Offshore Wind Infrastructure*.

Our organizations support the CEC's leadership to advance responsible offshore wind development and recognize that it creates an important pathway for combatting climate change and developing a green economy. At the same time, offshore wind must be developed in a responsible manner, minimizing environmental impacts, while protecting biodiversity, cultural resources, public health, and other ocean uses.[1]

This letter provides information on the following topics, responding to CEC's questions 1, 2, 4, 6, 8, 9, 10:

- Information on entanglement risks, including gear types that could be entangled and marine life that could be entangled;
- Technologies, equipment, and types of inspection that could detect entanglement;

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[1] Specifically, responsible renewable energy development: (1) avoids, minimizes, mitigates, and monitors for adverse impacts on wildlife and habitats; (2) minimizes negative impacts on other ocean uses; (3) includes robust consultation with Native American Tribes and communities; (4) meaningfully engages state and local governments and interested parties from the outset; (5) includes comprehensive efforts to avoid negative impacts and bring benefits to underserved communities; and (6) uses the best available scientific and technological data to ensure science-based and stakeholder-informed decision making.

- Structural integrity or environmental monitoring technologies that could be used to detect entanglement;
- Environmental inspections and other types of monitoring protocols that could be used to detect entanglements; and
- Cost estimates of different monitoring technologies.

1. **Information on Entanglement Risks**

Floating offshore wind relies on extensive networks of lines and cables to secure the floating platforms to the seabed, and to transmit energy from the turbines to floating substations and to shore. The resulting matrices create a sizable physical and ecological footprint, particularly for utility-scale projects, and could increase marine wildlife entanglement risks.

There are three classifications of marine entanglement potentially associated with floating offshore wind infrastructure — primary, secondary, and tertiary — with secondary entanglement representing the greatest potential risk for a broad range of species, such as seals, sharks, fish, diving sea birds, and sea turtles.[2] Primary entanglement involves animals becoming directly entangled in mooring lines and mid-water cables. Secondary entanglement refers to wildlife becoming caught in debris or other materials that may become ensnared on mooring lines, mid-water cables, or infrastructure. Offshore wind structures may also result in reef effects that could attract diving seabirds, potentially increasing secondary entanglement risk for these species. Tertiary entanglement could occur when debris or fishing gear already entangling an animal gets caught on and becomes anchored to project infrastructure. Primary and tertiary entanglement are currently considered less likely to occur than secondary entanglement, but ongoing monitoring and research are needed to improve scientific understanding of the relative risk posed by the three classes of entanglement.[3]

No primary entanglement events of large marine mammals have been documented in offshore oil platforms that use catenary mooring systems similar to those used in floating offshore wind contexts.[4] However, the lack of comprehensive monitoring of these oil and gas systems, and the absence of inter-array cabling in offshore oil platforms, precludes concluding low risk levels exist for either context.[5] Certain floating offshore wind turbine design features may partially account for the lack of documented primary entanglement events, such as the use of larger-diameter mooring lines and chains that are less likely to form loops in which marine species can become ensnared. Large diameter mooring cables and

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[2] Benjamins, S., Harnois, V., Smith, H.C.M., Johanning, L., Greenhill, L., Carter, C. and Wilson, B. "Understanding the potential for marine megafauna entanglement risk from renewable marine energy developments." Scottish Natural Heritage Commissioned Report No. 791 at 1-2 (2014). https://tethys.pnnl.gov/sites/default/files/publications/SNH-2014-Report791.pdf

[3] SEER [U.S. Offshore Wind Synthesis of Environmental Effects Research]. "Risk to marine life from marine debris & floating offshore wind cable systems" (Winter 2022). https://tethys.pnnl.gov/sites/default/files/summaries/SEER-Educational-Research-Brief-Entanglement-Considerations.pdf; Farr, Hayley, Benjamin Ruttenberg, Ryan K. Walter, Yi-Hui Wang, and Crow White. "Potential environmental effects of deepwater floating offshore wind energy facilities." *Ocean & Coastal Management* 207 (2021): 105611. https://doi.org/10.1016/j.ocecoaman.2021.105611.

[4] *Id.*

[5] SEER 2022.

chains are also likely large enough to be detected by most large marine species with the highest entanglement risks via echolocation, vibrations, or acoustic detection.[6]

Limited monitoring data from operational floating wind projects have similarly not indicated an accumulation of secondary entanglement hazards or incidence of primary or tertiary entanglements. However, surveys of existing floating wind infrastructure have been conducted infrequently (e.g., once every two years) meaning that it is not possible to say definitively whether any marine entanglements or accumulation of entanglement hazards have occurred. It is possible that entangled animals and accumulated hazards could become dislodged, removed, or otherwise disappear between surveys. Additionally, certain at-risk species (e.g., baleen whales) are not found in large numbers in areas where floating offshore wind has been developed to date, meaning that it is not possible to conclude that these species are not at risk from the lack of reported entanglements so far. Moreover, it may take time for floating offshore wind infrastructure to acquire fish-aggregating ‘reef effects’ that attract diving seabirds.

Additional data collection is needed to fully understand the entanglement risks of floating offshore wind deployment; however, the severity of its effects in other industrial settings are well established and the current paucity of data for floating offshore wind does not rule out the existence of entanglement risks.[7] Studies show that entanglement can cause asphyxiation, tissue damage, reduced foraging ability, impaired mobility, and impacts on fitness and population growth, especially for species with low reproductive rates.[8] The low likelihood but high severity nature of entanglements associated with offshore wind infrastructure warrants a precautionary risk management approach.

Both active fishing gear and abandoned, lost or otherwise discarded fishing gear (ALDFG) and other marine debris can cause secondary or tertiary entanglement of marine wildlife in floating offshore wind infrastructure. It is important to consider the overlap of historical and potential future fishing efforts with the location of floating offshore wind projects with respect to entanglement risk. Derelict fishing gear constitutes a significant percentage of marine debris – the National Oceanic and Atmospheric Administration (NOAA) estimates that fishing gear makes up ten percent of marine debris worldwide and suggests that this will only increase with time as fishing efforts increase; while other studies show fishing gear representing an even greater proportion of marine debris.[9] Floating offshore wind infrastructure that overlaps with, or is closely situated to, fishing areas may be more likely to accumulate ALDFG or other marine debris that may result in heightened secondary entanglement risk. In addition, fishing gear (both in-use and ALDFG) is responsible for a significant portion of current whale entanglements including those off the coast of California–in 2022, for example, it caused at least forty percent of known entanglement events.[10] The introduction of floating offshore wind infrastructure could potentially add to

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[6] Maxwell, Sara M., Francine Kershaw, Cameron C. Locke, Melinda G. Conners, Cyndi Dawson, Sandy Aylesworth, Rebecca Loomis, and Andrew F. Johnson. "Potential impacts of floating wind turbine technology for marine species and habitats." *Journal of Environmental Management* 307 (2022): 114577. https://doi.org/10.1016/j.jenvman.2022.114577.

[7] Benjamins at al. at 4-6.

[8] SEER 2022, Benjamins et al. at 11-12.

[9] NOAA. “Impact of Ghost Fishing via Derelict Fishing Gear. NOAA Marine Debris Program” (2015). https://marinedebris.noaa.gov/wildlife-and-habitat-impacts/impact-ghost-fishing-derelict-fishing-gear; Lebreton, Laurent, Boyan Slat, Francesco Ferrari, Bruno Sainte-Rose, Jen Aitken, Robert Marthouse, Sara Hajbane et al. "Evidence that the Great Pacific Garbage Patch is rapidly accumulating plastic." *Scientific Reports*, 8, no. 1 (2018): 1-15. https://doi.org/10.1038/s41598-018-22939-w.

[10] NOAA. “National Report on Large Whale Entanglements Confirmed in the United States in 2022” (2024). https://www.fisheries.noaa.gov/s3//2024-01/National-Report-Large-Whale-Entanglement-2022-508.pdf.

or exacerbate existing entanglement risks for several protected species that are already experiencing unsustainable levels of entanglements in these regions.[11] The prospect of such potential impacts further warrants a proactive approach to managing this risk factor in the floating offshore wind context in California. In addition, as there are currently no floating offshore wind systems in the U.S., requirements for management and mitigation have not been developed or refined by federal and state agencies. Often these permit requirements influence which technology and instrumentation is needed to fulfill risk mitigation measures. We encourage CEC to work with partner agencies in exploring the technology applicable for entangled debris monitoring to ensure the process will inform and support the eventual requirements.

The footprint of the underwater infrastructure associated with future commercial-scale floating wind projects planned for the U.S. will also be much larger than the small-scale projects constructed to date. The risk of marine debris accumulation and entanglement risk will likely increase along with the size of the project footprint, given the increase in the number and length of cables, number of platforms, etc.[12] It will be crucial to assess the cumulative effects of multiple, utility-scale floating wind projects on marine life.

2. Technologies and Equipment that Could Detect Entanglements or Entanglement Risk and Recommendations for their Deployment

Integration of monitoring technologies with offshore wind platforms, combined with routine inspections of the lease area and effective response protocols, will improve management of the potential entanglement risks posed by floating offshore wind infrastructure. Monitoring for entanglement risk in floating offshore wind projects could be undertaken by adapting technologies used for periodic surveys of underwater infrastructure, environmental monitoring, and continuous automated detection of increased load on cables, which are already deployed in other industrial and/or research applications.

By implementing both continuous, automated monitoring and routine inspections and surveys of all floating offshore wind array mooring lines and inter-array cables, operators can be promptly alerted to heightened risk factors. These include the presence of sensitive species with high entanglement risks, accumulation of secondary entanglement hazards such as ALDFG, and biofouling on lines and cables. Marine debris and various types of fishing gear could become entangled in these structures at any depth. All floating offshore wind turbine arrays must incorporate monitoring technology that, even if not a part of a continuous, automated monitoring system, can monitor the full depth extent of a given project.

As the efficacy of automated and remote monitoring technologies and techniques is still being researched, it is important to conduct frequent, on-site surveys. These can both determine the overall effectiveness of remote systems and establish a baseline for entanglement events and accumulation of secondary hazards.

Additional research is needed to develop effective monitoring systems, appropriate monitoring requirements (e.g., how often inspections should be required) and ensure proper application of available technology. Existing data from the oil and gas industry's experience with mooring system monitoring offers valuable insights for floating offshore wind operations.[13] However, the oil and gas industry's expertise on mooring systems, while substantial, may not be directly transferable to the floating offshore

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[11] *Id*.

[12] Maxwell et al. 2022.

[13] Ciuriuc, Alexandra, José Ignacio Rapha, Raúl Guanche, and José Luis Domínguez-García. "Digital tools for floating offshore wind turbines (FOWT): A state of the art." *Energy Reports* 8 (2022): 1207-1228. https://doi.org/10.1016/j.egyr.2021.12.034.

wind context, since offshore oil platforms do not include key elements of floating offshore wind platforms, such as inter-array cables, and should not be used as a substitute for developing monitoring systems best suited for the floating offshore wind activities.

This section provides an overview of currently available monitoring technologies, including additional research needs, and our initial recommendations on how existing technologies can be deployed to support monitoring for entanglement risk.[14]

a. Automated Underwater Vessels (AUVs), Remotely Operated Vehicles (ROVs), and Towfish

Unmanned systems towed behind a vessel ("towfish") and automated underwater vehicles (AUVs) and remotely operated vehicles (ROVs) can provide high-quality, large area monitoring capabilities and can be outfitted with a variety of scientific and monitoring equipment, including passive acoustic monitoring (PAM) devices, sonar systems, and video and still photography equipment. Imaging systems with cameras and lasers, or Light Detection and Ranging (LiDAR) also represent potential options for AUVs deployed in close vicinity to the cable.

The choice between AUVs and ROVs should be based on factors like the total number of floating turbines in a given array, the distance of the array from shore (i.e., its accessibility), and the depth capabilities that allow for full coverage of the floating offshore wind array footprint. It may be optimal to deploy a combination of ROVs and AUVs. ROV surveys, while more costly, offer greater flexibility and could facilitate the immediate retrieval of floating debris during line and cable inspections; however, they should be deployed in specific circumstances with low risk of entanglement or ensnarement of the technology itself on project infrastructure. AUV surveys may lower the overall costs of more frequent survey efforts, potentially allowing a small staff on land, with a standby vessel available. A benefit of AUVs is that they can be programmed to follow a given survey path, potentially increasing the frequency of floating offshore wind turbine array monitoring by reducing the staff, equipment, and fuel costs associated with vessel deployed towfish surveys. Alternatively, conducting all inspection operations using a crewed vessel deploying an AUV to conduct autonomous surveys could also be an effective option, especially if the frequency of inspections drops. A vessel with an AUV specialist could conduct other routine operations and maintenance activities while the AUV completes the inspection, either running fully autonomously or piloted by the shipboard AUV specialist.

Additional Research Needs

Towfish and AUVs are extensively used in a variety of marine operations and are well suited for monitoring offshore wind infrastructure. However, because of the unique nature and limited experience applying AUV and towfish surveys specifically to floating offshore wind platforms, some limited research

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[14] The technologies presented in this report were assessed through a comprehensive literature review and outreach study examining current floating offshore wind design risk assessments, monitoring methods and constraints, and monitoring and mitigation recommendations. The literature review included peer-reviewed literature and “grey” literature, such as technical reports and floating turbine array proposals from government and industry. The outreach study consisted of interviews conducted with marine industry professionals and scientists who are actively working on solutions to address floating offshore wind monitoring needs.

Example makes and models of different technology platforms were either selected from data presented in a 2020 review of subsea cable monitoring technologies compiled by Eleftherakis and Vincen-Bueno (2020) or identified during expert interviews. Special consideration was given when selecting sonar systems to avoid any potential adverse effects of sonar frequencies and volumes on the marine environment. (*See* Eleftherakis, Dimitrios, and Raul Vicen-Bueno. "Sensors to increase the security of underwater communication cables: A review of underwater monitoring sensors." *Sensors* 20, no. 3 (2020): 737. https://doi.org/10.3390/s20030737).

or pilot studies will be required to ensure that these technologies can be effectively used to monitor offshore wind platforms. While there is no reason to expect that workflows and procedures will differ from those of existing AUV and towfish efforts, potential differences and challenges are unknown and additional research is needed to effectively adapt these technologies for use with floating offshore wind platforms.

Refinement of self-docking AUVs that could dock at-depth is underway, and may be applicable to monitoring of offshore wind infrastructure.[15] The battery life, residence time, and instrument capabilities of these AUVs could be examined through pilot or demonstration studies at state-managed decommissioned oil and gas platforms.[16] Testing should be conducted over multiple years to account for the impacts of seawater on monitoring devices and varying seasonal ocean conditions.

Select example AUV platforms (adapted from Eleftherakis and Vincen-Bueno 2020)

Make and Model	Range (km)	Endurance (hr)	Depth (m)	Supported Sensors / Capacity (where provided)
Hydroid Remus 600	133	24	600	Side-scan sonar, video cameras, still cameras
Kongsberg Munin / Henin	133	24	1500	Multibeam sonar, side-scan sonar, still cameras
Gavia Teledyne Marine	28 – 133	5 – 8 can be extended to 15 – 24 with addition of extra batteries	1000	Optional USBL, Multibeam sonar, sidescan sonar, camera

b. Acoustic sonar monitoring and surveys

Underwater acoustic sonar systems -- which use noise to detect marine life and/or underwater objects – are extensively used for a variety of marine monitoring and detection in a variety of marine industries. Sidescan sonar and multibeam backscatter systems specifically are commonly used for ALDFG location and retrieval in Canadian and U.S. waters and are well suited for monitoring for entanglements and accumulation of entanglement hazards.[17]

Omnidirectional Multibeam Sonar

Modern fish-finding sonar systems use advanced sonar transducers to maximize coverage area and image fidelity with omnidirectional systems capable of monitoring a full 360°. These omnidirectional units may be suited for stationary deployments facing down underneath floating offshore wind platforms or spars

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[15] *See*, *e.g.*, deep-water, self-docking AUV being developed by SAAB capable of inspecting underwater infrastructure. https://www.saab.com/products/sabertooth.

[16] Multiple types of monitoring technology could be tested in pilot projects as the State Lands Commission advances decommissioning of oil and gas platforms in state waters, *see*, *e.g*., Platform Holly, https://www.slc.ca.gov/oil-and-gas/southellwood/.

[17] Drinkwin, Joan, Kyle Antonelis, and Max Calloway. “Methods to Locate and Remove Lost Fishing Gear from Marine Waters.” Prepared for the Department of Fisheries and Oceans Canada Sustainable Fisheries Solutions and Retrieval Support program. Natural Resources Consultants. Seattle, WA. https://www.researchgate.net/publication/368751774_Methods_to_Locate_and_Remove_Lost_Fishing_Gear_from_Marine_Waters_Prepared_for_Department_of_Fisheries_and_Oceans_Canada_Sustainable_Fisheries_Solutions_and_Retrieval_Support_Program_Activity_5_Part_B.

where they may be able to monitor for anomalies autonomously and continuously along mooring and portions of inter-array cables.

However, many commercially available, omnidirectional fish-finding sonar operational frequencies overlap with those used for hearing and vocalization by baleen whales, toothed whales, fish, and seals and sea lions.[18] For example, many commercial grade, omnidirectional fish finders produced operate at frequencies that overlap with the known hearing and vocalization frequencies (10 to 100 kHz) of both beaked whales and southern resident killer whales.[19] Care should be taken to select multibeam systems that operate at peak frequencies above the range of marine mammal audibility and with no or minimal leakage of sound within the range of marine mammal audibility. Systems should also be capable of being mounted underneath individual floating offshore wind platforms.

Side Scan Sonar

Side-scan sonar provides higher resolution acoustic imagery than single- or multi-beam sonars and generally operates at higher frequency ranges on the high-end of toothed whale hearing and vocalization frequencies (200 kHz to 400 kHz). Side-scan sonar relies on thin, high-frequency bands, shot at oblique angles to survey targets to provide high-fidelity acoustic images. While the high-detail imagery side-scan sonar provides is valuable in accurate target identification, it also requires that surveys be conducted close to the target substrate.

Additional Research Needs

Use of omnidirectional multibeam sonars for monitoring mooring lines will need to be field tested to determine the effectiveness and sensitivity of these systems for detecting both marine species presence, and accumulation of secondary entanglement hazards on mooring lines and cables. In addition, research should be conducted on how multiple, continuously operating sonar units will affect the overall increase noise footprint of floating offshore wind farms.

For use of acoustic sonar monitoring on AUVs, field testing is also needed to understand how the required instrumentation may impact the maneuverability, speed, and battery life of the AUV.

Select example multibeam and side-scan sonar units (adapted from Eleftherakis and Vincen-Bueno 2020)

Make and Manufacturer	Sonar Type	Platforms	Max. Depth (m)	Max. Range (m)	Frequency (kHz)	Beam Angle (°)
Kongsberg em2040-04	Multibeam	AUV	6000	400	200/300/400	165
Teledyne Seabat T20-S	Multibeam	AUV	6000	400 / 225	200/400	170

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[18] *See*, *e.g.*, Burnham, Rianna, Svein Vagle, Peter Van Buren, and Christie Morrison. "Spatial impact of recreational-grade echosounders and the implications for killer whales." *Journal of Marine Science and Engineering* 10, no. 9 (2022): 1267. https://doi.org/10.3390/jmse10091267; Holt, Marla M., Jennifer B. Tennessen, M. Bradley Hanson, Candice K. Emmons, Deborah A. Giles, Jeffrey T. Hogan, and Michael J. Ford. "Vessels and their sounds reduce prey capture effort by endangered killer whales (*Orcinus orca*)." *Marine Environmental Research* 170 (2021): 105429. https://doi.org/10.1016/j.marenvres.2021.105429.

[19] Burnham et al. *id.*

Biosonics Omnidirectional Marine Life Observer	Multibeam	Fixed	N/P	200 to 400	200	360
R2Sonic 2026	Multibeam	Vessel, ROV, AUV, ASV	4000	800	100/200/450	2/1/0.45
Klein UUV-3500	Side-scan	AUV	6000		75/100/400	
Kongsberg Geoswath Plus	Side-scan	AUV	4000	200/100/50	125/250/500	0.85/0.75/0.5
Klein system 5900	Side-scan	Towfish	750	N/P	600	N/P

c. Load Cells and Vibration Monitoring

Catenary and semi-taut mooring systems are designed to give enough dynamic range to a floating offshore wind platform to respond to dynamic wind, wave, and current conditions while subsea inter-array cables, especially at deeper sites, may be left free floating in the water column. Therefore, it is useful to monitor these systems for deviations from acceptable ranges.[20] Use of load cells and vibration sensors is common practice in many marine industries including on oil platform mooring systems and existing subsea electrical transmission cable. Load cells, installed at mooring line and cable attachment points, continuously monitor line and cable load, and can trigger automatic alerts in the event of load anomalies.

Load cells are sensors that can be used to measure the tension on equipment such as cables, ropes, and wires, and are used in various industries, including offshore oil and gas.[21] They come in many varieties, with high-capacity load shackles – where a U-shaped shackle is used to carry or contain the load – as likely the most appropriate for the high loads and harsh environments characteristic of offshore wind operations. Additionally, load cells generally either monitor direct or indirect loads. Because indirect load cells monitor for deviations in load along all axes except the primary load axis, they may be more suitable for detection of anomalies caused by accumulated entanglement hazards or entanglements themselves. At least one research project is currently being underway to determine if this technology is capable of detecting marine debris fouling and wildlife entanglements.[22]

Distributed Acoustic Sensor (DAS) technology uses fiber optic cables to detect acoustic vibrations along the entire length of the cable, allowing for continuous monitoring of the cable's condition and detecting any changes or anomalies in real-time. DAS technology works by using a laser to send pulses of light

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[20] Ciuriuc et al. 2022.

[21] *See e.g.,* U.S. Cargo Control, Straightpoint Load Monitoring Load Cells. https://www.uscargocontrol.com/collections/straightpoint-load-monitoring-loadcells.

[22] California Energy Commission Energize Innovation, “Integrated Monitoring Approach to Reduce Entanglement Hazards for Floating Offshore Wind Developments.” Awarded to Cal Poly Humboldt Sponsored Programs Foundation, Agreement Number EPC-23-006, Project Term: 8/1/2023-3/31/2027. https://www.energizeinnovation.fund/projects/integrated-monitoring-approach-reduce-entanglement-hazards-floating-offshore-wind.

through the fiber optic cable. When the light encounters an acoustic vibration, such as those caused by mechanical stress, it scatters and reflects back to the sensor. This scattered light can then be analyzed to determine the location, intensity, and frequency of the acoustic vibration. By analyzing these acoustic signals, DAS technology can detect changes in the cable's condition, such as the presence of cracks, breaks, or other defects. It can also identify changes in temperature, pressure, and other environmental factors that may affect the cable's performance or lifespan.

DAS technology has several advantages for cable monitoring, including its ability to monitor the entire length of the cable continuously, its high sensitivity and accuracy, and its ability to detect and locate small defects before they become more serious problems.[23] DAS can also be multi-use, with capabilities for environmental monitoring (marine mammal calls, water temperature) as well as infrastructure monitoring, using different interrogators on the same cables in a system.[24]

Additional Research Needs

It is currently unknown whether the tolerance ranges of existing load cells and vibration sensors are sensitive enough to identify an accumulation of ALDFG and/or marine entanglements in floating offshore wind infrastructure, or in associated cable infrastructure like transmission cables. Testing and modeling efforts will be required to determine the detection capabilities of commercially available load cells and vibration sensors, including parameters that might affect those capabilities (such as water depth, the depth a cable is buried, whether there are any bends in the cable), and if such sensors will ultimately be suited for entanglement mitigation and monitoring.

Systems for incorporating fiber cables capable of DAS directly into floating offshore wind infrastructure into the manufacturing process need to be explored. Fiber cables should have enough protection to maintain structural integrity. Additional testing is needed to simulate the strain of ensnared gear to distinguish and localize ensnarements and entanglements, in both field and laboratory settings. DAS is capable of measuring a number of factors anywhere along the length of a fiber, but additional research is needed to combine and distinguish modes of signals.

d. Wave actuated cable-crawlers

Wave actuated cable-crawlers are vehicles that rely on water motion and ratcheting clamps to move along the mooring cable (rather than a predetermined program), and can be equipped with sensors powered by lithium batteries. Wave actuated cable crawlers have the potential to detect entanglements or ensnared marine debris along a mooring cable or anchor line; however, current systems are focused on oceanographic data collection and not currently compatible with the monitoring technology most useful for entanglement mitigation (i.e., sonar systems).

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[23] Ghazali, Muhammad Farid, Hisham Mohamad, Muhammad Yusoff Mohd Nasir, Alarifi Hamzh, Muhammad Aizzuddin Abdullah, Nor Faiqa Abd Aziz, Phromphat Thansirichaisree, and Mohd Saiful Dzulkefly Zan. "State-of-The-Art application and challenges of optical fibre distributed acoustic sensing in civil engineering." *Optical Fiber Technology* 87 (2024): 103911.https://doi.org/10.1016/j.yofte.2024.103911.

[24] Wilcock, William SD, Shima Abadi, and Bradley P. Lipovsky. "Distributed acoustic sensing recordings of low-frequency whale calls and ship noise offshore Central Oregon." *JASA Express Letters* 3, no. 2 (2023). https://doi.org/10.1121/10.0017104. Pelaez Quiñones, Julián David, Anthony Sladen, Aurelien Ponte, Itzhak Lior, Jean-Paul Ampuero, Diane Rivet, Samuel Meulé, Frédéric Bouchette, Ivane Pairaud, and Paschal Coyle. "High resolution seafloor thermometry for internal wave and upwelling monitoring using Distributed Acoustic Sensing." Scientific Reports 13, no. 1 (2023): 17459. https://doi.org/10.1038/s41598-023-44635-0.

Additional Research Needs

Significant research and development are needed to retrofit currently available cable-crawler systems to be compatible with floating offshore wind mooring cables and chains.[25] Current cable crawler systems do not appear to support sonar instrumentation and future development of cable-crawler systems for use in floating offshore wind entanglement mitigation should focus on compatibility with sonar units and the ability to automatically clean and reduce biofouling on lines and cables.[26]

e. Recommendations for Using Existing Technologies and Methods to Monitor and Mitigate for Entanglement Risk

To ensure adequate monitoring of entanglement risk in floating offshore wind infrastructure, the technology options described should be used for the following purposes.

Install loadcells and vibration sensors to continuously monitor mooring lines and inter-array cables for sudden or significant changes in load or increase in vibration.

Floating offshore wind mooring lines should be equipped with load cells with sufficient detection resolution to detect both significant accumulations of secondary hazards and for entanglement events. Likewise, inter-array cables should have vibration and fault sensors as well and load cells at all floating infrastructure attachment points, and potentially at accessory buoy attachment points if present.

Attach down facing omnidirectional multibeam sonar to the bottoms of all floating platforms.

Omnidirectional multibeam systems with automatic detection capabilities sufficient to detect secondary entanglement hazards as well as marine species presence in and around the floating offshore wind array (e.g., Biosonics Omnidirectional Marine Life Observer) should be installed facing down to the underside of each floating offshore wind platform. It is crucial to consider the impacts of underwater noise generated by these systems on marine mammals and other marine life. To minimize those impacts, multibeam systems used should operate at peak frequencies above the range of marine mammal audibility and with no or minimal leakage of sound within this range.

Include regular sonar inspections of all mooring lines and inter-array cables via AUV or surface vessel deployed sonar surveys in management plans.

Sidescan and multibeam sonar systems are routinely used in submerged infrastructure inspection and monitoring. Proposed offshore wind projects require the use of submersible ROVs or AUVs for installation and regular operations and maintenance activities, making them the logical choice for survey deployment. Due to significant gaps in knowledge of the relative risk of secondary entanglement, the full length of the submerged infrastructure (including platforms, substations, mooring lines, inter- array cables, and anchors, as well as monitoring technology docking stations or other infrastructure, as appropriate) should be surveyed on a monthly basis for at least the first year of operation. Survey frequency thereafter should be informed by the findings of the first year of monitoring but should still occur at least annually. Seasonal migration, feeding, and breeding of marine species, as well as the instance of hurricanes or large storms, may necessitate more frequent surveys.

Use passive acoustic monitoring within floating offshore wind arrays to automatically detect the presence of vocalizing marine species and to trigger follow-up monitoring.

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[25] Maxwell et al. 2022.

[26] Maxwell et al. 2022.

Passive acoustic monitoring (PAM) technology can detect whale presence over a considerable area, with the exact detection ranges varying by species and oceanographic conditions. Existing detection algorithms can automatically identify many/some species-specific vocalizations in near real time, and future developments may enable the automated identification of additional species.

Protocols could be developed for use if vocalizing marine species are detected within proximity to floating offshore wind arrays. For example, a relative increase in automated PAM alerts may indicate increased species presence within an area and could be used trigger immediate follow-up surveys of the array's subsurface infrastructure for accumulated entanglement risks. This could serve as a low-cost method for increasing on-site infrastructure monitoring for entanglement risks, within an adaptive management framework.

The PAM arrays should ensure total coverage of the lease area. If PAM arrays become useful for the automated detection of other relevant acoustic anomalies, the number and location of PAM arrays should be adapted to detect them, as well. Given the limitations of PAM, observers and other technologies should also be used as part of monitoring systems, in order to ensure more reliable data about species' presence and appropriate responses.

3. <u>Environmental Inspections and Other Types of Monitoring and Mitigation Protocols</u>

a. Floating Offshore Wind Platforms Should Be Sited and Designed to Avoid Entanglement Risks

Preventing entanglement must be a fundamental goal in floating offshore wind siting, construction, and operation and maintenance plans, with monitoring and mitigation serving as secondary and tertiary lines of defense. As part of this strategy, early-stage environmental site assessments should be conducted to avoid areas of importance for endangered and protected marine species. Environmental impact statements (EISs), as well as construction and operations plans, should detail mooring and inter-array cable configurations, with a focus on factors that most directly influence entanglement risk, such as diameter of cable, tautness, the number of lines, and material used in lines.[27] Incorporating consideration of these factors into public documents enhances understanding of their contribution to potential entanglement risk and supports a precautionary approach to floating offshore wind operation.

Avoid leasing in migratory corridors, foraging and socializing areas, and any other important habitat of an at-risk species.

The siting of offshore wind projects must account for and avoid, whenever possible, areas where at-risk species are present or engaging in foraging behaviors.[28] If it is not possible to entirely exclude these areas from site selection, then it is imperative to avoid areas of highest use by vulnerable species, as well as high-biodiversity habitats, such as kelp forest and coral reefs. Some technologies for monitoring entanglement risk may also be useful for characterizing marine faunal presence and use of proposed lease sites.

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[27] Maxwell et al. 2022.

[28] NRDC [Natural Resources Defense Council]. "Monitoring of Marine Life During Offshore Wind Energy Development—Guidelines and Recommendations" (March 2023). https://www.nrdc.org/sites/default/files/ow_marine-life_monitoring_guidelines.pdf.

Require floating offshore wind anchoring and mooring systems to use large-diameter wire rope or cable and avoid chains or synthetic fiber ropes.

The specific characteristics of mooring systems, such as line material, tautness, and diameter, may be critical in determining entanglement risk. Large diameter steel wire rope or cable is typically expected to pose the lowest risk compared to steel chain or synthetic fiber rope due to its smoother surface, which reduces the likelihood of snagging.

Require floating offshore wind anchoring and mooring systems to use taut or semi-taut configurations and avoid catenary mooring systems.

Among the mooring system types, taut and semi-taut configurations are generally safer than catenary systems because they have less slack. Additionally, larger diameter lines can help in maintaining tautness and avoiding loops, thereby further reducing the risk of potential entanglement. As noted above, large diameter wire rope or cable should be used, and chains and synthetic fiber ropes should be avoided due to their higher snagging potential.

Bury inter-array cables whenever possible and require minimum depths for free floating cables.

To minimize potential entanglement risk, inter-array cables linking individual floating offshore wind turbines and turbine arrays to land-based infrastructure should be buried whenever possible. This approach not only reduces the likelihood of primary entanglement but also diminishes the risk of secondary entanglement due to accumulated debris. Considerations related to cost and benthic habitat impacts will need to be taken into account when evaluating this option.

In deeper waters where burial is not feasible, the depth at which cables are suspended should account for various factors, including presence of at-risk species, and conflicts with fishing activities. In cases where burial is not practical, suspending inter-array cables at a minimum depth that falls below the deeper boundaries of the foraging zones of at-risk species is recommended.[29] It is also important to consider the types of mooring systems and turbines used in an array, which determine a project's footprint. In many cases, the minimum depth may be more than 200 meters.

Use large diameter accessory buoys to stabilize inter-array cables.

Large-diameter accessory buoys, approximately 2 meters in size, can potentially reduce entanglement risk by significantly enhancing the stability of catenary mooring lines and free-floating inter-array cables.[30] Such buoys are already used to help stabilize catenary mooring lines and free-floating inter-array cables and to protect them from stressors such as high wind, large waves, and general inclement weather. By providing additional buoyancy and stability, they may reduce the risk of entanglement and ensure the durability and longevity of the mooring lines and cables in the challenging marine environment.

Design infrastructure to facilitate visual or acoustic detection of ensnared marine debris.

Infrastructure design features can facilitate visual or acoustic detection of ensnared marine debris by monitoring equipment and personnel. For example, lighter coloration of infrastructure can aid the visual

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[29] Copping, Andrea and Grear, Molly. "Humpback Whale Encounter with Offshore Wind Mooring Lines and Inter-Array Cables." Prepared by Pacific Northwest National Laboratory for the Bureau of Ocean Energy Management under an Interagency Agreement with the U.S. Department of Energy. Pacific Norwest National Laboratory, Richland, WA (2018).

[30] *Id.*

detection of often darker colored marine debris, and use of textures that contrast with marine debris can aid acoustic detection at depths where light is limited.

b. Operators Should Follow Standard Protocols to Respond to Entanglement Events

If entanglements are identified through monitoring, a well-defined protocol is essential to respond promptly and to mitigate resulting harm to ocean wildlife and ecosystems. Protocols should facilitate rapid response to detected entanglements and ensure on-call availability of response teams if heightened risks entanglement are detected. Protocols should also clearly define the working relationships between, and respective roles of, local and regional marine species rescue and rehabilitation organizations.

Initial protocols are proposed below:

- If monitoring reveals that sharks and/or diving or plunging marine birds are entangled in marine debris on any project structure, the lessee must promptly notify the National Marine Fisheries Service (NMFS) or U.S. Fish and Wildlife Service (USFWS), the U.S. Coast Guard, and the relevant state agency as soon as possible, and within 6 hours of detection. The lessee must remove the marine debris and any entangled sharks or diving or plunging marine birds as soon as possible following discovery, in a manner determined by the appropriate federal and state agencies and that does not jeopardize human safety, property, or the environment.
- In cases where marine mammals or sea turtles are entangled in marine debris ensnared on a project structure, the lessee must follow the Reporting Protocol for Injured or Stranded Marine Mammals or the sea turtle reporting protocol developed by the Sea Turtle Disentanglement Network. The lessee must provide the federal and relevant state agencies with all available information on the incident.
- Finally, if monitoring shows that debris has become ensnared on any project structure, without entanglement of marine mammals, sea turtles, sharks, or diving bird species, the lessee must notify the NMFS or USFWS, the U.S. Coast Guard, and relevant state agency within 24 hours of detection. The lessee again must remove the marine debris as soon as possible following its discovery, while ensuring human safety, property, and the environment are not compromised.

c. Operators Should Maintain Equipment and Staff to Respond to Marine Debris Ensnarements (i.e., Secondary Entanglement Risk)

A varied fleet of vessels is needed to aid with regular operations and maintenance activities, and developers should ensure that at least some of the vessels in their fleet have features and capabilities for the location and removal of marine debris that has become ensnared on project infrastructure. This will help reduce secondary entanglement risk. These features include length of 40 feet or more, winches or cranes with load capacities suitable for commercial fishing, suitability for both SCUBA and surface-supply air diving, and abilities to launch, operate, and retrieve an ROV or AUV.

d. Operators Should Ensure Data Availability and Transparency

Offshore wind developers should also be required to adhere to federal and relevant state derelict fishing gear and marine debris survey, disposal, recovery, and reporting requirements. California, Oregon, and Washington each have established systems for the reporting of lost fishing gear, which have proven valuable in ALDFG mitigation, location, and retrieval. Floating offshore wind arrays should be integrated into existing reporting systems, with a priority on reporting fishing gear lost within proximity of currently operating floating wind arrays to reduce the risk of secondary entanglement. Additionally, fishers should have a system to report gear loss or ALDGF gear sightings within offshore floating wind infrastructure, which could be integrated into existing gear loss reporting programs, offering a streamlined method for managing and mitigating the risks associated with lost or adrift fishing gear in the vicinity of floating offshore wind projects.

All baseline, monitoring, incident and assessment data should be made publicly available and shared with standard metadata conventions used by the Marine Cadastre, the U.S. Integrated Ocean Observing System (IOOS), regional ocean data portals, or other long-term collaborative data-management efforts.[31] To facilitate long-term access, data could be hosted by an independent entity – for example, the Northeast Regional Ocean Council[32] and California Offshore Wind Energy Gateway both currently provide access to regional data on marine life, seafloor habitat, and other data relevant to planning for offshore wind development.

Data should promptly be made publicly available. Frequent reporting is necessary to alert agencies, lessees, and the public to impacts in a timely manner and to enable avoidance, minimization, and mitigation of adverse impacts throughout all phases of development, operations, and decommissioning.

4. Cost Estimates of Different Types of Technologies

Cost estimates were developed using example technology for each of the monitoring systems recommended. Sales quotes were then obtained and used to calculate potential costs for pilot and utility scale arrays. Examples chosen for presented cost estimates do not represent an endorsement of one make or model over another, instead they are representative examples of the capabilities and technical specifications suited for offshore wind monitoring and survey work. The number of units per individual floating offshore wind turbine were dependent on whether the technology would need to be installed on every mooring line or the floating platform. For technologies used on an array-wide scale the number of recommended units was based off detection area (PAM) or range and endurance (AUV). It is possible that larger arrays may benefit from bulk ordering, however this was not considered while developing estimates.

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[31] We recommend incorporation of the detailed recommendations for data transparency and equitable data sharing found in Amy Trice et al., “Challenges and Opportunities for Ocean Data to Advance Conservation and Management,” OCEAN CONSERVANCY (2021), https://oceanconservancy.org/smart-ocean-planning/take-deep-dive/oceandatareport/; *see also,* California Ocean Observing Systems Data Portal: https://data.caloos.org/.

[32] *See* Northeast Ocean Data Portal Work Plan: https://neoceanplanning.org/data-issues/northeast-ocean-data-portal-work-plan/; California Offshore Wind Energy Gateway: https://caoffshorewind.databasin.org/; or the California Ocean Observing Systems Data Portal: https://data.caloos.org/.

Selected monitoring technologies and estimated cost at pilot (9 floating turbines) and commercial (100 floating turbines) scales.

Equipment	Monitoring Type	Utility	Make	Model	Est. Unit Cost	Unit	Pilot Scale Array (9 turbines)	Commercial Scale Array (100 turbines)
Passive Acoustic Monitoring	Fixed Continuous	Automated acoustic alerts		Real-time alert cable system w/ 2, 4 Hydrophone Arrays	NA	NA	$1,500,000 per year	$1,500,000 per year
Omnidirectional Sonar	Fixed Continuous	Automated perimeter alerts and continuous sonar monitoring of mooring lines	Biosonics	Omnidirectional Marine Life Observer	$250,000.00	1	$2,250,000	$25,000,000
Load Cells	Fixed Continuous	Automated detection of load anomalies	Scotload	150-ton load shackle bundle	$7,722.00	5	$347,490	$3,861,000
Vibration Monitor*	Fixed Continuous	Automated detection of excesses vibration or movement				4		
AUV**	Regular surveys	Automated or remote piloted platform with multibeam sonar, side scan sonar, and real time video instrumentation	Teledyne Marine	Gavia	$1,500,000.00	NA	$3,000,000 (2 units)	$7,500,000 (5 units)
Boat & Towfish/ROV		Surveys of mooring lines			$8,000 to $20,000 per day		$16,000 to $40,000 (estimated two days of work	$160,000 to $400,000 (estimated 20 days of work)

** Several options are currently in development and may be available within one year of writing.*

*** Total AUVs per project were calculated assuming (1) Vessel deployment within the floating offshore wind array; (2) theoretical maximum AUV of 133 km; (3) Four, 1 km survey lengths consisting of three mooring lines and a single inter-array cable per floating turbine; (4) At least one backup AUV.*

Monitoring technologies and protocols for floating offshore wind infrastructure will likely be similar across projects regardless of mooring design.[33] However, the mooring system, along with the total number of floating turbines in each array, determines the footprint of an individual floating turbine and of the overall project, and

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[33] Maxwell et al. 2022.

may affect the costs of comprehensive monitoring systems. Catenary mooring systems with their more extensive footprint will potentially be more costly to monitor.

5. Conclusion

Until it becomes feasible to collect long-term, empirical data on the relative risk of entanglement posed by floating offshore wind infrastructure, it is imperative that this risk factor be managed in a precautionary manner. The potential impacts to California's marine life, including endangered and threatened species already experiencing unsustainable numbers of entanglements in fishing gear, as well as to the floating offshore wind industry if entanglements were found to occur without protective measures in place, mean that a proactive approach must be taken on this issue. Many technologies and protocols already exist that would allow floating offshore wind developers to proactively and effectively reduce potential entanglement risks to marine mammals and other marine life. Other solutions are on the horizon, which, with adequate, near-term investment, could help further reduce these risks. We appreciate CEC considering these comments and would be pleased to discuss matters in more detail.

Sincerely,

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