I. Monitoring and Adaptive Management Approach

Define the problem or management objective.
- Determine potential effects of the project on indicator species.
- Emphasis on examining potentially negative, rather than neutral or positive, effects.
- Emphasis on examining objectives that are "measurable".

Design and Implement
- Monitoring plans to address objectives based on the potential effect on indicator species, or at a minimum, exposure of the indicator species to the potential effect.
- Mitigation measures to reduce potential effects.
- Determine threshold values that, if surpassed, would likely cause negative or unacceptable effects on indicator species.

Monitoring and Reporting Requirements
- Establish "triggers" for additional measures (i.e., surpasses known threshold values).
- Evaluate results of monitoring, and success of mitigation measures, through periodic reporting to decision-making group.

Adaptive Management
- Revise or extend monitoring studies based on evaluation of reported results
- Develop additional mitigation measures if known threshold values surpassed.
- Modify project if necessary to avoid significant adverse impacts
- Decisions should be by consensus.

II. Potential Effects, Monitoring Studies & Mitigation

Noise
Potential effects: Noise emitted from WEC devices could mask communication signals and environmental cues, disturbing navigation, foraging, and detection of predators for marine mammals. At higher intensities, noise could cause temporary threshold shifts and avoidance of area for marine mammals.

Monitoring Approach:
- Measure ambient (pre-project) and project-associated noise under a range of sea states and model propagation with autonomous recorders, boat based recordings, and hydrophones connected to shore cable data lines.
- Compare device noise to known marine mammal hearing sensitivities and vocalizations to estimate injury and masking effects.
- Determine need for further study (i.e., improve knowledge of vocal behavior of local species, improve propagation models, modification of equipment to reduce noise).
- Monitor marine mammal use of project area to determine "exposure risk" using passive acoustic monitoring of marine mammals and direct observations (boat surveys).

Adaptive Management: Modify equipment to reduce noise (i.e., cable strumming).

Methods	Notes
Autonomous fixed recorders deployed individually or as vertical arrays suspended in water column to evaluate ambient and device noise, and occurrence of cetacean species to assess exposure risk.	Relatively inexpensive battery powered digital recorders, continuous data collection, can be configured to record any range of frequencies, continuously or sample on a duty cycle. Deployment duration potentially long term, limited by sampling rate and data storage capacity.
Small boat based recordings using dangling hydrophones to evaluate ambient and device noise, and vocalizations of cetaceans in area.	Boat time expensive, good for short-term data collection to extend range, density of data, fill in data gaps
Hydrophones connected to cable to shore to evaluate ambient and device noise, and occurrence of cetacean species to assess exposure risk.	Relatively inexpensive, can record wide range of frequencies, be configured as an array to estimate distance to vocalizing species, limited to locations along cable.
Passive acoustic detection of ultrasonic odontocete echolocation pulses using autonomous devices to assess exposure risk (i.e., T-Pods for harbor porpoise)	Analyzes echolocation pulses and stores detection time and characteristics, can be programmed for one or several species and any duty cycle, cover the ultrasonic spectrum allowing other devices to sample at a lower rate.
Direct observations (boat surveys) of marine mammals to assess exposure risk	Relatively expensive and time consuming (need year-round data), need several years of data for distribution data, some data already available

Electric and Magnetic Fields (EMF)

Potential effects: EMF emitted from WEC devices and associated power transmission cables could affect navigation, behavior, and/or orientation of elasmobranchs, salmon, sturgeon, Dungeness crab, sea turtles, cetaceans and other marine organisms. EMF could disrupt migration of salmonids and sturgeon.

Monitoring approach:

- Measure ambient and project-induced EMF, EMF generated by other projects, power cables, etc.
- Compare to extensive literature review of sensitivity thresholds.
- Based on results, determine if additional information is warranted.
- If necessary, examine neurophysiological/behavioral effects on key species.

Adaptive Management: Shielding and burial of cables, “Faraday Cages” around devices.

Entanglement

Potential effects: Marine mammals could become entangled in lost fishing gear hung up on WEC devices.

Monitoring approach:

- Monitor WEC devices, moorings and anchors periodically using ROV or SCUBA to detect and remove accumulated lost gear and/or entangled marine mammals. Determine how frequently monitoring should occur and potential monitoring triggers (e.g., after large storms). Characterize types of lost gear, determine source(s) when possible, duration in sea.
- Monitor marine mammal use of project area to determine “exposure risk” using passive acoustic monitoring of marine mammals and direct observations (boat surveys).

Adaptive Management: Install “pingers” to repel marine mammals from area if entanglement occurs.

Methods	Notes
ROV observations at WEC devices to detect lost gear or entangled marine mammals	Relatively expensive, could be combined with regular O&M
SCUBA observations at WEC devices to detect lost gear or entangled marine mammals	Relatively expensive, could be combined with regular O&M
Passive acoustic monitoring of marine mammals to assess exposure risk using autonomous recording devices (i.e., click detectors such as T-Pods for harbor porpoise)	Analyzes sounds real time and records time and type of click, can be programmed for one or several species and any duty cycle
Direct observations (boat surveys) of marine mammals to assess exposure risk	Relatively expensive and time consuming (need year-round data), need several years of data for distribution data, some data already available

Collisions with Vessels

Potential effects: Vessels involved with construction, maintenance, and decommissioning could collide with marine mammals, causing injury and/or mortality.

Monitoring Approach:

- Monitor marine mammal use of project area to determine "exposure risk" using passive acoustic monitoring and/or direct observations. Combine with entanglement and O&M monitoring.

Adaptive Management:

- Establish vessel speed limits, obtain take permits, vessel observers to monitor exposure and take.
- Avoid areas or times (seasonal, diurnal, etc.) where collision risks are highest.

Artificial reef, FAD effects, and Biofouling

Potential effects:

- The WEC devices could attract fish and invertebrate species and marine mammals near the surface (FAD effect) and on the seabed (reef effect), causing changes to local community composition. The structures could also act as a marine reserve due to exclusion of fishing.
- Biofouling of structures could occur, and result in changes to benthic habitat (shell mounds).
- The structures could attract and facilitate the spread of invasive species.
- Attraction to the structures could result in increased predation on listed fish species by marine mammals or fish predators.

Monitoring approach:

- Evaluate if project is attracting fish as FAD or artificial reef. Methods could include visual observations (ROV or SCUBA), hook and line, trapping, trawling, grab samples, settlement plates, and gillnets.

Adaptive Management: Modify structures to prevent pinniped haul-outs. Unknown if other mitigation measures needed.

Methods	Notes
ROV observations at WEC devices (evaluates reef and FAD effects, and biofouling/shell mounds)	Relatively expensive, visibility could be an issue, good for observations of fish associated with structures at surface, moorings and anchors
SCUBA observations at WEC devices (evaluates reef and FAD effects, and biofouling/shell mounds)	Relatively expensive, visibility could be an issue, good for observations of fish associated with structures at surface, moorings and anchors, good for collecting biofouling organisms

Trapping (evaluates reef effects)	Relatively inexpensive, probably works only for certain species especially Dungeness crab and some rockfishes
Bottom trawling (evaluates reef effects)	Relatively expensive, surveys for demersal fishes and invertebrates, may not be feasible in project footprint once project deployed. Can obtain specimens to examine food habits
Grab samples (evaluates effects to benthic infauna)	Relatively expensive especially identification, provides information on benthic infauna.
Purse seine (evaluates FAD effects)	Relatively expensive, samples pelagic fishes, and likely not possible to use once project deployed.
Gill nets (evaluates FAD effects)	Relatively inexpensive, samples pelagic fishes (not likely to be usable at depth due to moorings). Likely to result in mortality of fishes captured. Can obtain specimens to evaluate food habits.
Hook and line (evaluates FAD effects, and if listed fish or fish predators attracted to devices)	Relatively inexpensive. Can obtain specimens to evaluate food habits.
Settlement plates (evaluates biofouling and invasive species)	Plates relatively inexpensive but analysis could be expensive.

Attraction to WEC devices for foraging, haul-outs, roosting

Potential effects: Attraction to the devices because of increased forage, or to haul out on structures, could expose marine mammals and seabirds to other impacts (i.e., entanglement). It could also contribute to an increase in predation by marine mammals on listed fish species (i.e., salmon).

Monitoring approach:

- Monitor marine mammal use of project area to determine "exposure risk" using passive acoustic monitoring and/or direct observations.
- Install cameras on WEC devices to detect hauling out or roosting on structures.

Adaptive Management:

- Modify structures to prevent pinniped haul-outs and/or roosting.
- Install "pingers" to repel marine mammals from area.

III. Additional Potential Issues Considered

1. Effects on benthic fauna from smothering/anchors, alteration and loss of benthic habitat/community. Study not proposed because effects short-term and highly localized.
2. Cable laying disturbance depending on if left on surface or buried. Study not proposed because project currently proposes to bury cables, and effects would be very localized and short-term.
3. Shading. Study not proposed because effects highly localized and negligible (no shade effect below 20 m due to scatter and low visibility).
4. Entrainment/impingement. Study not proposed because effects unlikely with device design.
5. Collisions between marine mammals and WEC devices. Study not proposed because effects unlikely with device design and with marine mammal's ability to detect and avoid solid structures.
6. Lighting above and below water. Study not proposed because lights on WEC devices not very bright, limited to navigation lights.

7. Physical effects such as changes to wave energy, littoral transport, alteration of bottom substrates, sediment transport, and sediment deposition. HSU will be studying effects on substrate and transport.
8. Effects on Dungeness crab. Study proposed for EMF effects (see above). Reedsport study will provide information on effects of WEC structures on distribution and abundance that will be applicable to WaveConnect.
9. Effects of contaminants (paints, coatings, fluids) on water quality, sediment. Study not proposed because effects can be minimized through proper handling of chemicals, etc.
10. Degradation of water quality (turbidity, chemical toxicity, temperature, pH, DO, salinity). Study not proposed because identifying the root cause of the degradation as the WEC project is highly unlikely except in the case of an unusual source of pollution unique to the project
11. Heat generated by the cables, especially the buried ones. Measurable heat generation not expected; it is preferred to bury cables for improved heat dissipation versus in water.