Evaluating the Potential for Marine and Hydrokinetic Devices to become Artificial Reefs or Fish Aggregating Devices based on the Analysis of Surrogates in Tropical, Subtropical, and Temperate US West Coast and Hawaiian Coastal Waters

Dr. Sharon Kramer, H. T. Harvey & Associates

1125 16th Suite 209
Arcata, CA 95521

Phone: (707) 822-4141 FAX: (707) 822-4848 E-mail: skramer@harveyecology.com

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LONG-TERM GOALS

Our goal was to evaluate the potential ecosystem interactions that may be associated with marine and hydrokinetic (MHK) devices in coastal waters off the U.S. West Coast and Hawai'i.

OBJECTIVES

Our objective was to evaluate the potential for MHK devices to function as artificial reefs or fish aggregating devices (FADs). We based our evaluation on an analysis of surrogate structures located in tropical, subtropical, and temperate coastal waters on the U.S. West Coast and Hawai'i.

APPROACH AND WORK PLAN

1. **Approach:** The approach was to review literature and assess the potential for MHK devices to function as FADs and/or artificial reefs, using studies on surrogate structures within four subregions: Southern California Bight; Central California to Cape Flattery, Washington; Puget Sound; and Hawai'i. Where information was lacking, guided discussions with resource managers and subject matter experts were conducted to obtain their personal direct observations and/or unpublished data to assist in the analysis.
2. **Key individuals:** Sharon Kramer was the PI on this project, ecologists Christine Hamilton and Greg Spencer assisted with the analysis, and Heather Ogston served as the technical editor. Dr. Peter Nelson (Collaborative Fisheries Research West) and David Itano (consultant) served as science advisors. Guided discussions were conducted with the following resource managers/experts: Dr. Kim Holland (Hawai'i Institute of Marine Biology), Michael Prall (California Department of Fish and Wildlife), Gavin Keys and Neil Sims (Kampachi Farms, LLC), Robert Pacunski (Washington Department of Fish and Wildlife), Dr. Robert Hannah (Oregon Department of Fish and Wildlife), Dr. Brian Tissot (Humboldt State University), Franklin Parker (U.S. Coast Guard), Eric Pedersen (Pacifico Aquaculture), Dr. Larry Allen (California State University, Northridge), Dick Stevenson (Retired commercial fisherman), Dr. David Ainley (H. T. Harvey & Associates), Alan Everson (National Marine Fisheries Service), and Dr. John Childers (NOAA Fisheries).

3. **Work plans for the upcoming year:** We will be submitting a version of the final report to a scientific journal for potential publication.

WORK COMPLETED

We completed **Task 2.0**, **Milestone 2.1, Task 3.0 and Milestones 3.1 and 3.2.**

- **Task 2.0 Analyze Impacts and Risks for Stressor-Receptor Interactions:** Based on our literature review and discussions with experts, we identified the fish species and ecological interactions most likely to be associated with FADs and artificial reef structures using surrogate structures, assessed the potential for MHK devices to function as FADs and/or artificial reefs within the four subregions (Southern California Bight; Central California to Cape Flattery, Washington; Puget Sound; and Hawai'i), and evaluated potential risks or negative effects of these structures on special-status fish species.

    - **Milestone 2.1.** A memorandum that includes the findings of the analysis of stressor-receptor interactions (*note: this was not completed separately, but was included with Milestone 3.1).

- **Task 3 Make Recommendations to Address Important Knowledge Gaps:** We identified and evaluated important knowledge gaps and recommended studies to address these gaps.

    - **Milestone 3.1.** A draft report that included the findings from Task 2.0, and an evaluation of knowledge gaps and recommended studies.

    - **Milestone 3.2.** A final report that addressed comments from DOE/BOEM.

RESULTS

The structures associated with wave energy converters (WECs) and tidal energy converters (TECs) placed on to the seabed, such as anchors and foundations, may function as artificial reefs that attract reef-associated fishes, while the midwater and surface structures, such as mooring lines, buoys, and wave or tidal power devices, may function as fish aggregating devices (FADs), forming the nuclei for groups of fishes. We evaluated the potential ecological interactions with WECs and TECs by reviewing relevant information about fish associations with *surrogate structures*, including artificial reefs, natural reefs, kelps, floating debris, oil and gas platforms, marine debris, anchored FADs deployed to enhance fishing opportunities, net-cages used for mariculture, and piers and docks.

Based on our review, we postulate that the structures of WECs and TECs placed on or near the seabed in coastal waters of the U.S. West Coast and Hawai'i likely will function as small-scale artificial reefs and attract potentially high densities of reef-associated fishes (including special-status rockfish species [*Sebastes* spp.] along the U.S. West Coast), and that the midwater and surface structures of WECs placed in the tropical waters of Hawai'i likely will function as *de facto* FADs with species assemblages varying by distance from shore and deployment depth. Along the U.S. West Coast, frequent associations with midwater and surface structures may be less likely: juvenile, semipelagic, kelp-associated rockfishes may occur at midwater and surface structures of WECs in coastal waters of southern California to Washington, and occasional, seasonal, or transitory associations of coastal pelagic fishes such as jack mackerel (*Trachurus symmetricus*) may also occur at WECs in these waters. Importantly, our review indicated that negative effects of WEC structures on special-status fish species, such as increased predation of juvenile salmonids or rockfishes, are not likely. In addition, WECs installed in coastal California, especially in southern California waters, have the potential to attract high densities of reef-

associated fishes and may even contribute to rockfish productivity, if fish respond to the WECs similarly to oil and gas platforms, which have some of the highest secondary production per unit area of seafloor of any marine habitat studied globally (Claisse et al. 2014).

We encountered some information gaps, owing to a lack, in key locations, of comparable surrogate structures in which fish assemblages and ecological interactions were studied. TECs are most likely to be used in the Puget Sound area, but suitable surrogates are lacking there. However, in similarly cold-temperate waters of Europe and Maine, benthopelagic fish occurred around tidal turbines during lower tidal velocities, and this type of interaction may be expected by similar species at TECs in Puget Sound. To address information gaps in the near term, such as whether WECs would function as FADs in temperate waters, studies of existing structure such as navigation buoys, are recommended.

RELATED PROJECTS

Closely-related projects that H.T. Harvey & Associates have been involved in include:

For Bureau of Ocean Energy Management: West Coast Environmental Protocols Framework: Baseline and Monitoring Studies (Klure et al. 2012). http://tethys.pnnl.gov/publications/west-coast-environmental-protocols-framework

For U.S. Department of Energy: Deployment Effects of Marine Renewable Energy Technologies - Framework for Identifying Key Environmental Concerns in Marine Renewable Energy Projects (Kramer et al. 2010) http://tethys.pnnl.gov/publications/framework-identifying-key-environmental-concerns-marine-renewable-energy-projects

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Personal Communications

Allen, Larry. Marine Fish Ecologist. California State University, Northridge. 8 September 2014—guided discussion with Sharon Kramer and Christine Hamilton of H. T. Harvey & Associates, regarding the potential for structures to function as artificial reefs and FADs in California waters.

Childers, John. Marine Fish Biologist. National Oceanic and Atmospheric Administration Fisheries. 23 September 2014—electronic mail correspondence with Sharon Kramer of H. T. Harvey & Associates, regarding the potential for structures to function as FADs in California waters.

Everson, Alan. National Marine Fisheries Service. 18 September 2014—guided discussion with Gregory Spencer of H. T. Harvey & Associates, regarding the response of fish to offshore and coastal fish culture and other types of structures in Hawaiian waters.

Hannah, Robert. Marine Fisheries Researcher. Oregon Department of Fish and Wildlife. 21 August 2014—guided discussion with Sharon Kramer and Christine Hamilton of H. T. Harvey & Associates, regarding fish use of natural rocky reefs in coastal Oregon waters.

Holland, Kim. Marine Fish Ecologist. Hawai'i Institute of Marine Biology, University of Hawai'i at Manoa. 18 September 2014—guided discussion with Gregory Spencer of H. T. Harvey & Associates, regarding the potential for structures to function as FADs and response by pelagic fish in Hawaiian waters.
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