LIVING SHORELINES PROJECT REPORT

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for the Honda Marine Science Foundation Board

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INTRODUCTION

The Honda Marine Science Foundation's guiding philosophy of *sato-umi* promotes harmonious coexistence between humans and marine life within coastal ecosystems. Living shorelines restoration projects build on this philosophy by enhancing coastal resilience and supporting biodiversity through the use of natural structures as an alternative to shoreline armoring. They provide ecosystem services including shoreline protection and habitat value, while presenting an excellent opportunity for community engagement and collaboration among diverse groups of stakeholders.

While living shorelines address climate change and sea level rise using innovative approaches, they are highly context-dependent and their success relies on collaboration of interdisciplinary teams. Gathering insight from a cross-disciplinary group of practitioners representing different communities is necessary to determine areas of greatest need and opportunities for most impactful funding.

This report provides a summary of current challenges and opportunities in living shorelines research through a brief literature review and a series of interviews with practitioners from a variety of disciplines. It identifies scientific knowledge gaps and opportunities to fund innovative approaches to improving coastal resilience.

SUMMARY: STATE OF THE SCIENCE

Before conducting stakeholder interviews, an initial review was conducted of relevant literature, including conference proceedings, living shorelines meetings and workshop reports, papers from scientific journals and magazines, and mission statements from other small foundations dedicated to supporting marine conservation and coastal restoration. This review provided preliminary insight into key knowledge gaps, major themes in living shorelines and innovation, and potential stakeholders to interview.

Several overarching themes were evident in reviewing the current state of the science. First, the concept of living shorelines to stabilize shorelines and preserve habitat value is still relatively new, particularly on the Pacific coast (Bilkovic et al. 2016, Engeman 2018, Zedler et al. 1996). Restoration designs therefore often draw from East coast case studies and need to be adapted to Pacific shorelines, which are characterized by more open coast area and shoreline hardening (Engeman 2018, Gittman et al. 2015, Hanak & Moreno 2008). Demonstration projects testing new techniques and evaluating the likelihood of their success along the Pacific coast need to be more widespread (Russell & Griggs 2012, Saleh & Weinstein 2016, State Coastal Conservancy et al. 2010). Compilations of case studies varying by landscape setting, energy level, and habitat type are a work in progress, but a more concentrated effort in developing these resources is needed (Beagle et al. 2019, Judge et al. 2017, Smith et al. 2020, State Coastal Conservancy et al. 2010).

Once assembled, such compilations can be used to create regional restoration guidelines and implement standardized monitoring methods.

There is a great need for quantitative assessments of long-term structural integrity of living shorelines, as well as research into their maintenance requirements and success in adapting to rising sea levels. Another widely cited knowledge gap is a lack of projects directly comparing the effects of "green" or natural versus "gray" or artificial structures. The incorporation of any artificial element into a living shorelines design is controversial among living shorelines practitioners (Engeman 2018, Moosavi 2017, Pilkey et al. 2012). While some advocates of hybrid green-gray approaches are encouraged by the durability of artificial elements in the face of high wave energy, many biologists are concerned that small-scale habitat restoration adjacent to armoring will add little ecological value and do nothing to address the problem of hardened shorelines (Pilkey et al. 2012). Living shorelines themselves, when in the proper coastal setting, have been documented to be more effective in reducing the impacts of storms than armored structures (Bilkovic et al. 2016). However, in open coast, high energy environments, success is limited (Walker et al. 2011). More research into these high-energy coastal contexts, especially during extreme weather events, is needed (Saleh & Weinstein 2016, Hanak & Moreno 2008, Gittman et al. 2015). Detailed risk assessments and hazard modeling are imperative in understanding the durability of living shorelines into the future and assessing the role they will play in reducing flood risk (Aerts et al. 2018, Myszewski et al. 2016, Reguero et al. 2018, Russell & Griggs 2012).

Long-term monitoring of ecosystem services has been highlighted by numerous sources as another essential component to living shorelines success, especially regarding wave attenuation, faunal community response, and carbon sequestration (Benayas et al. 2009, Bilkovic et al. 2016, Davis et al. 2015, Gittman et al. 2016, Patrick et al. 2016, Pilkey et al. 2012, Simenstad et al. 2006, Zeigler et al. 2018). These long-term data convey the success or failure of nature-based infrastructure at meeting its coastal resilience goals, and are needed to assure coastal property managers, landowners, and policymakers that their investment in natural alternatives to shoreline armoring is worthwhile. Next steps include streamlining communication between science and management and improving public perception of living shorelines (Belcher et al. 2019, Currin 2019, Engeman 2018, Russell & Griggs 2016, Smith et al. 2020). Clearer communication of living shorelines benefits to the public using concrete examples will establish ground-up demand and lead to the institutional capacity building required for larger-scale implementation (RAE 2015). In short, a number of logistical and sociological hurdles underly the major knowledge gaps in living shorelines research, indicating areas where support is most needed.

PRACTITIONER SELECTION & INTERVIEW QUESTIONS

Practitioners were selected with the goal of equally representing different disciplines, organization types, and regions along the Pacific coast. A preliminary list of potential contacts was created throughout the literature review process, with significant input from project advisors recommending stakeholders they were connected or familiar with throughout the Pacific coast. Several practitioners that had previously received HMSF grants were also contacted for interviews, as they were familiar with HMSF's mission and grant process and could recommend next steps for the foundation based on this knowledge. More potential interviewees were identified as interviews progressed; many practitioners provided recommendations or connections, and/or suggested perspectives that needed greater representation in the field.

While the final list of practitioners interviewed spanned several disciplines and organization types, it is important to note that increased representation is always needed moving forward for native communities and communities of color. Ensuring that these communities form a substantial part of discussions on living shorelines is integral to addressing their concerns and promoting projects that advance their interests and well-being.

Interviewees were selected from nonprofit and grassroots organizations, state and federal agencies, academia, consulting and engineering firms, and funding groups. Biologists, ecologists, oceanographers, engineers, policy specialists, and stakeholder engagement professionals all participated in interviews 25 minutes in length or longer.

The following interview questions were asked to each practitioner:

1. How does your current role and/or background contribute to advancements in living shorelines research and community engagement?

2. What have you found to be the biggest challenges or barriers in advancing living shorelines research? Are there ways that small foundations could provide support in working past those barriers?

3. What projects and programs do you think are most needed to help advance living shorelines and on-the-ground climate resilience measures?

4. What areas are you eager to explore next in your research, and what limitations will you face in doing so? (i.e. regulations/permitting, funding, training, resource availability)

5. What innovative restoration methodologies would you be interested in learning more about, both in your community and in other regions? Are there specific novel techniques for increasing coastal climate resilience that you think need more support or attention?

6. What are the needs to help enhance scalability of living shorelines projects beyond individual locations? How might a small foundation best target these needs?

7. How is your living shorelines research being used by practitioners and/or exposed to the public, and how might this be improved upon?

8. Are you seeking any new partnerships or methods of community engagement that would be particularly valuable in accomplishing your project goals?

9. Is the scientific community well organized and in strong communication around advancements in living shorelines science and solutions? If so, how can it be further supported? If not, what would help enhance organization and communications?

RESULTS

A total of 23 interviews were conducted with living shorelines practitioners. The major challenges and barriers to living shorelines advancement identified varied to some extent by discipline, but many responses were common or interconnected among interviewees (Table 1).

Table 1. Commonly identified challenges and knowledge gaps in living shorelines research, organized by number of mentions by practitioners (≥10 in green; 5 to 9 in orange; < 5 in yellow).

Common Needs & Challenges	Examples & Action Needed	Mentions
Long-Term Monitoring	Need for 10+ years of data on living shorelines durability, adaptation, ecological response, & ecosystem services	13
Demonstration Projects	Pilot projects in new communities and varied coastal contexts	13
Engineer Training and Resources	Design guidelines, standardized methods, and training/certification programs in natural infrastructure	13
Communications Campaigns	Social media outreach, video projects, community environmental education	12
Green-to-Gray Spectrum	Need for direct comparisons of man-made and natural structures and case studies in high-energy environments	11
Cross-Disciplinary Networks	Increased communication and data/results sharing between scientists and professionals, policymakers	11
Success Rate	Need for data on living shorelines' efficacy in achieving long-term goals (i.e. coastal protection and habitat value)	11
Visualizations	Maps, imaging, drone photos, virtual reality, models, apps; any way to display projects and gain community attention	10
Consistent Living Shoreline Definition	Disagreements on what habitat types, coastal contexts, and structural elements constitute living shorelines	9
West Coast Guidelines & Examples	Regional compilations of shoreline designs appropriate for different settings, expanding on successes and failures	9
Permit Streamlining	Pilot-scale, streamlined permitting with easily accessible checklists to enable more efficient preparation	8
Environmental Justice & Equity	Need for outreach in under-served communities	5
Dialogue Between Communities	Sharing concerns, stories, goals, successes, challenges	5
Assessment of Public Perception	Stakeholder outreach (i.e. public meetings, webinars, surveys)	5
Documentation of Timeline & Cost	Availability of information (material cost, permitting timelines, project maintenance) to streamline future work	4
Regulatory Agencies	Increased advocacy to demonstrate importance of living shorelines and maintain funding	3
Building Ground-up Demand	Increasing community support for healthy natural coastlines and extending support beyond scientific community	2

The majority of practitioners confirmed that one of the most pressing challenges is a lack of long-term data evaluating how living shorelines projects are meeting their specific goals along the Pacific coast. Projects are often monitored for a few years past their implementation, generally up to about five years with few exceptions. There is a simultaneous need for more demonstration projects to begin and for monitoring of existing projects to continue (Smith et al. 2020, Zeigler et al. 2018). West coast living shorelines studies require further research into project lifespan, standardized timelines and monitoring methods, and effective restoration materials in different coastal settings. A growing network of professionals and collaborative effort to share data and methods is needed to guide future research and streamline restoration processes in the future.

Interviewees across multiple disciplines and organization types identified a great need for capacity building when it comes to living shorelines restoration, especially professional training programs. Many practitioners mentioned a lack of engineers trained in nature-based infrastructure and familiar with its unique benefits and challenges. Availability of certified training programs for coastal engineers interested in living shorelines is needed. For living shorelines to become a more widely used engineering practice, long-term studies of durability, adaptation, and maintenance needs are also essential, especially in high-energy environments. Specific regional design guidelines should be created to distinguish which techniques have succeeded and failed in a given coastal setting. These specifications can inform trainings and information sessions for interested practitioners and can refine the method selection process when designing future projects.

Regulatory agencies were also identified by multiple stakeholders as an area where further work is greatly needed. Policymakers rely on concrete evidence that living shorelines work as intended, and this is not achievable without ample scientific support and effective communication. Maintaining dialogue between science and management will improve regulatory agencies' understanding of living shorelines projects as well as researchers' understanding of permitting requirements. Streamlining the permitting process for future projects will enable new living shorelines projects to get off the ground more efficiently and will make them an accessible strategy for more communities and small nonprofits. Finally, increased community engagement and data sharing is needed to shift public perceptions of living shorelines and promote the concept of natural beaches and their benefits.

To address the challenges listed above, interviewees proposed a wide range of solutions from innovative restoration studies to educational programs and communications campaigns. The most commonly mentioned approaches are outlined in Table 2.

Table 2. Opportunities for supporting innovative restoration techniques and programs, by number of interviews in which each was discussed (≥10 green; 5-9 orange; 2-5 yellow; one-off suggestions in white).

Methodologies & Research Areas	Examples	Mentions
Green-gray hybrid structures	Studies directly comparing benefits and drawbacks of nature-based infrastructure, and/or assessing the incorporation of limited man-made materials in high-energy environments	11
Open coast and offshore studies	Studies assessing offshore vegetation efforts (i.e. kelp and eelgrass restoration) and resulting changes in sediment deposition, especially as shorelines migrate	10
Hazard and risk modeling	Predictions for long-term adaptation and durability, addressing rising sea levels and ability to withstand disturbance	7
High wave energy settings	New approaches to restoration in high-energy environments	7
Community science	Involving the local community in long-term data collection to both educate and build a collaborative dataset	6
Identifying future habitat	Projects that plan ahead and identify habitat/land areas that will be needed for managed retreat	6
Cobble studies	Recommended by engineers: research into the use of cobble as a natural infrastructure material (e.g. durability, movement)	5
Preparation for public meetings	Providing food, arranging webinars, bringing people together	5
Dune revegetation	Recommended by engineers: research into revegetated dunes and how they grow, accumulate sediment, and protect shores over time	4
Ecosystem service quantification	Studies calculating the economic value of services provided by restoration (water clarity, biodiversity, storm protection)	3
Extreme weather events	Studies addressing ability to protect against storm surges	3
Experimental design	Studies with randomized, replicated experimental designs	3
Shell recycling programs	Building a growing network of local restaurants and businesses as partners, providing shell for oyster restoration	2
Multiple habitat types	Connecting as many habitats as possible from subtidal to upland	2
Dredge sediment monitoring and placement	One USACE program, “Innovative Shore Protection”, once monitored dredge sediments and needs replacement. These sediments could be put to use in sea level rise mitigation efforts.	1
Community-based subsistence areas	Collaboration between local government and community; i.e., indigenous fish ponds and community subsistence areas in HI	1
Natural reef balls	Alternatives to artificial reef balls used in oyster restoration	1
High-relief oyster beds	Need for taller oyster bed structures given the low relief of Olympia oyster beds; Baycrete may be a helpful material	1

Groundwater-based natural infrastructure	Using nature-based infrastructure in groundwater, where adaptability is important and armoring is undesirable	1
Increasing accommodation space	Projects focused on increasing the amount of space between wave action and hardened structures	1
Stormwater irrigation	Using stormwater to maintain restored habitats, potentially used in a larger-scale project such as a horizontal levee	1
Drought studies	Natural irrigation techniques for drought periods where restored vegetation may begin to die off	1

The discussion and recommendation section overviews many of the most commonly referenced suggestions for specific project types, but several one-off suggestions are listed in Table 2 as well. Some of these include unconfined sediment placement from dredge material as a method of sea level rise mitigation (Baptist et al. 2019); analysis of nature-based infrastructure in groundwater studies, where adaptability is a clear advantage over armoring (Silvertooth et al. 2019); and research into natural irrigation techniques for restoration projects during drought periods. Other suggestions were specific to oyster restoration, including the development and use of natural reef balls, the implementation of shell recycling programs and networks, and the creation of higher-relief oyster beds for greater structural stability. Finally, increasing the accommodation space between coastlines and hardened structures to accommodate wave action was identified specifically in one interview as a valuable research area, though this echoed the needs outlined by many interviewees.

CONCLUSION

After reviewing recent literature on living shorelines and gathering insight from a varied group of cross-disciplinary practitioners, the most effective areas of funding were identified as the following: (1) Funding demonstration projects in their early research stages, (2) supporting projects and trainings for engineers utilizing nature-based infrastructure, (3) contributing towards long-term monitoring of both ecological and structural properties, (4) communicating findings, importance, and project visualizations to stakeholders within and between communities, and (5) advancing the causes of environmental justice and equity.

REFERENCES

Aerts, J. C., Barnard, P. L., Botzen, W., Grifman, P., Hart, J. F., De Moel, H., ... & Sadrpour, N. (2018). Pathways to resilience: adapting to sea level rise in Los Angeles. *Annals of the New York Academy of Sciences*, *1427*(1), 1-90.

Baptist, M., Vroom, J., Willemsem, P., Puijenbroek, M., van Maren, B., van Steijn, P., ... & Colosimo, I. (2019). Beneficial use of dredged sediment to enhance salt marsh development by applying a 'Mud Motor': Evaluation based on monitoring (No. C088/19). *Ecoshape*.

Bilkovic, D. M., Mitchell, M., Mason, P., & Duhring, K. (2016). The role of living shorelines as estuarine habitat conservation strategies. *Coastal Management*, 44(3), 161-174.

Beagle, J., Lowe, J., McKnight, K., Safran, S., Tam, L., & Szambelan, S. J. (2019). *San Francisco Bay Shoreline Adaptation Atlas: Working with Nature to Plan for Sea Level Rise Using Operational Landscape Units* (No. SFEI publication# 915).

California State Coastal Conservancy and Ocean Protection Council, NOAA National Marine Fisheries Service and Restoration Center, San Francisco Bay Conservation and Development Commission, & San Francisco Estuary Partnership. (2010). *San Francisco Bay Subtidal Habitat Goals Report*. Oakland, California, United States.

California State Coastal Conservancy. (2019). Justice, Equity, Diversity, and Inclusion (JEDI) Guidelines.

Chang, K., Young, C., Asuncion, B., Ito, W., Winter, K., & Tanaka, W. (2019). Kuaʻāina Ulu ʻAuamo: Grassroots Growing through Shared Responsibility. In W. LaDuke (Ed.), *Indigenous food sovereignty in the United States: restoring cultural knowledge, protecting environments, and regaining health.* (Vol. 18). University of Oklahoma Press.

Currin, C. A. (2019). Living Shorelines for Coastal Resilience. In *Coastal Wetlands* (pp. 1023-1053). Elsevier.

Engeman, L. (2018). Living Shorelines & Resilience in Southern California: A Summary of a Series of Workshops held as part of The Resilient Coastlines Project of Greater San Diego.

Gittman, R. K., Fodrie, F. J., Popowich, A. M., Keller, D. A., Bruno, J. F., Currin, C. A., ... & Piehler, M. F. (2015). Engineering away our natural defenses: an analysis of shoreline hardening in the US. *Frontiers in Ecology and the Environment*, 13(6), 301-307.

Gittman, R., Scyphers, S., Smith, C., Neylan, I., & Grabowski, J. (2016). Ecological consequences of shoreline hardening: A meta-analysis. *BioScience*, 66(9).

Hanak, E., & Moreno, G. (2012). California coastal management with a changing climate. *Climatic Change*, 111(1), 45-73.

Judge, J., Newkirk, S., Leo, K., Heady, W., Hayden, M., Veloz, S., ... & Small, M. (2017). Case Studies of Natural Shoreline Infrastructure in Coastal California: A Component of Identification of Natural Infrastructure Options for Adapting to Sea Level Rise (California's 4th Climate Change Assessment). *Arlington: The Nature Conservancy, 38p*.

Kurth, M., Ali, R., Bridges, T., Suedel, B., & Linkov, I. (2020). Evaluating Resilience Co-Benefits of Engineering with Nature® Projects. *Frontiers in Ecology and Evolution*, *8*, 149.

Miller, J. K., Rella, A., Williams, A., & Sproule, E. (2015). Living shorelines engineering guidelines. *Stevens Institute of Technology*.

Moosavi, S. (2017). Ecological Coastal Protection: Pathways to Living Shorelines. Procedia Engineering. 196, pp. 930-938. Elsevier Ltd.

Moser, S., Hart, J., Mann, A., Sarpour, N., Grifman, P., & Brown, E. (2018). Growing effort, growing challenge: Findings from the 2016 California coastal adaptation needs assessment.

Myszewski, M., & Alber, M. (2016). Living Shorelines in the Southeast: Research and Data Gaps Prepared for the Governors South Atlantic Alliance.

National Estuary Program (NEP) Habitat Strategic Initiative. (2020). Shoreline Restoration Effectiveness in Puget Sound Monitoring Program Summary.

Pilkey, O. H., Young, R., Longo, N., & Coburn, A. (2012). Rethinking Living Shorelines. Cullowhee, North Carolina: Western Carolina University, White Paper, 10p.

Reguero, B. G., Beck, M. W., Bresch, D. N., Calil, J., & Meliane, I. (2018). Comparing the cost effectiveness of nature-based and coastal adaptation: A case study from the Gulf Coast of the United States. *PloS one*, *13*(4), e0192132.

Restore America's Estuaries. (2015). Living Shorelines: From Barriers to Opportunities. Arlington.

Russell, N., & Griggs, G. B. (2012). Adapting to sea-level rise: A guide for California's coastal communities. *University of California, Santa Cruz*, *31*.

Saleh, F., & Weinstein, M. P. (2016). The role of nature-based infrastructure (NBI) in coastal resiliency planning: A literature review. *Journal of environmental management*, *183*, 1088-1098.

Silvertooth, D. L., Neris, B. L., Solek, C. W., & Wilson, D. D. (2019, May). Green Infrastructure Inventory Review in Southern California. In World Environmental and Water Resources Congress 2019: *Groundwater, Sustainability, Hydro-Climate/Climate Change, and Environmental Engineering* (pp. 461-478). Reston, VA: American Society of Civil Engineers.

Simenstad, C., Reed, D., & Ford, M. (2006). When is restoration not? Incorporating landscape-scale processes to restore self-sustaining ecosystems in coastal wetland restoration. *Ecological Engineering,* 26, 27-39.

Smith, C., Rudd, M., Gittman, R., Melvin, E., Patterson, V., Renzi, J., . . . Silliman, B. (2020, 6 10). Coming to Terms With Living Shorelines: A Scoping Review of Novel Restoration Strategies for Shoreline Protection. *Frontiers in Marine Science,* 7.

Walker, R., Bendell, B., & Wallendorf, L. (2011). Defining engineering guidance for living shoreline projects. In *Coastal Engineering Practice (2011)* (pp. 1064-1077).

Winter, K. B., Beamer, K., Vaughan, M. B., Friedlander, A. M., Kido, M. H., Whitehead, A. N., ... & Nyberg, B. (2018). The Moku System: Managing biocultural resources for abundance within social-ecological regions in Hawai‘i. *Sustainability*, *10*(10), 3554.

Zedler, J. B. (1996). Coastal mitigation in southern California: the need for a regional restoration strategy. *Ecological Applications*, *6*(1), 84-93.

Ziegler, S. L., Grabowski, J. H., Baillie, C. J., & Fodrie, F. J. (2018). Effects of landscape setting on oyster reef structure and function largely persist more than a decade post-restoration. *Restoration Ecology*, *26*(5), 933-942.