The National Marine Research and Innovation Park

"If we want to make the best products, we also have to invest in the best ideas . . . Now is not the time to gut these job-creating investments in science and innovation. Now is the time to reach a level of research and development not seen since the height of the Space Race."

—President Barack Obama, State of the Union, February 2013

Humboldt Bay Harbor Recreation and Conservation District
Eureka, California

HUMBOLDT STATE UNIVERSITY **Arcata, California**

Conceptual Plan 1.1, March 2013

The NMRIP Idea

The idea for NMRIP springs from the belief that, as a nation, we need to sustain ourselves in ways that capitalize on our strengths and build on our internal resources—intellectual, physical and natural—and refocus us on our "sustainability infrastructure," including our youth, our natural resources, and our built environment.

Leveraging Regional Assets to Support National Priorities

The coastal communities in northern California have long combined the area's natural resources with a creative ingenuity to advance economic opportunities. Today, the region is seeking ways to transition from an economy largely dependent on resource extraction to one focusing on sustainable economic development. A unique opportunity now exists to apply regional expertise in marine-based research and technology development using a repurposed industrial facility.

The National Marine Research and Innovation Park (NMRIP), put forward by the Humboldt Bay Harbor Recreation and Conservation District (HBHRCD) and Humboldt State University (HSU), is a concept in development to repurpose a former pulp mill to a multi-use facility housing both research and commercial opportunities in aquaculture, biomass conversion, and renewable energy.

Aquaculture and renewable energy are well-matched to regional strengths and resources. NMRIP will be an important part of a national strategic approach to develop a more competitive, innovative and sustainable economy.

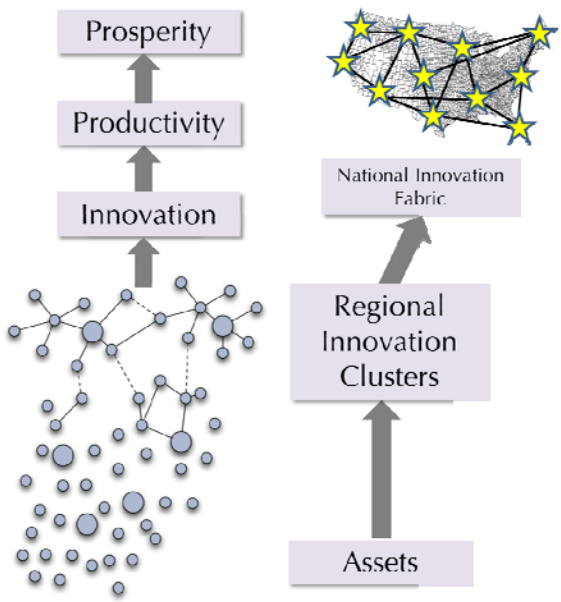
Forging a Vital Sustainability Infrastructure

The idea for the NMRIP springs from the belief that, as a nation, we need to sustain ourselves in ways that capitalize on our strengths, build on our internal resources—intellectual, physical and natural—and refocus us on our "sustainability infrastructure," including our youth, our natural resources, and our built environment.

The research, education and innovation focus at NMRIP represents an investment in the skills, education, and resources needed to prepare future generations to contribute creatively and productively to our nation. It will provide a valuable model for how regional economies can restore, sustain and develop capacities that foster economic well-being.

From Regional Assets to National Prosperity

- Increasing national food and energy security
- Supporting STEM education
- Providing innovation, economic and workforce development opportunities



Development of regional innovation clusters helps develop strong national fabric of research, learning and innovation—and leads to greater national prosperity.

Adapted from Ed Morrison and Strategy-Nets.

NMRIP proposed site: the Freshwater Tissue Pulp Mill. February 2013. ***Source: Pearse Narum***

Guiding the Economic Transition

NMRIP will be located on the historic Samoa Peninsula, a place which has employed thousands of workers and utilized hundreds of millions of dollars in industrial infrastructure. With its traditional livelihoods fading and resource-dependent industries in substantial decline, NMRIP will provide a critical opportunity to retool the area's economy. It will do this by drawing on regional competitive strengths, conducting state-of-the-art research, and producing commercially viable aquaculture and renewable energy technologies.

John Dolbeer's "Steam Donkey" exemplifies the region's legacy of innovation. ***Source: Wikipedia***

Arcata's innovative wastewater treatment marshes along Humboldt Bay. ***Source: Pearse Narum***

The North Coast Legacy: Creativity, Innovation and Hard Work

California's North Coast region is no stranger to innovation, invention and reinvention—from John Dolbeer's "steam donkey," which helped replace donkeys and oxen as the means of transporting logs, to the development of California's first railroads in 1854 and the drilling of California's first successful oil well in 1865, to continuing innovation today, such as using marshes as a natural wastewater treatment system—the region has shown great capacity for innovative resource development for over 150 years. To this day, the region is known for its entrepreneurial, innovative and hard working people.

Advancing Research, Education and Training

Experts from a wide range of natural resource and technology fields—including aquaculture, marine science, biotechnology, energy, and engineering—will find a home at NMRIP. This expertise will guide NMRIP's research, development and commercial application activities and inform technology entrepreneurs as they develop technologies that create new markets in the emerging green economy.

The R.V. *Coral Sea* is Humboldt State University's marine research and teaching vessel. The ship's capacity is 39 scientists and five crew, with 10 bunks and a full galley. Wide decks provide room for research and oceanographic equipment. Two laboratories inside offer space for marine specimens and monitoring environmental data.

Source: Humboldt State University

NMRIP will provide education and workforce development opportunities, including research activities for undergraduate and graduate students, learning spaces for PK-20 learners, and teacher education and professional development. A key asset of NMRIP is HSU's research vessel *Coral Sea*, the nation's only undergraduate oceangoing research vessel. The *Coral Sea* will provide opportunities for research and training at sea for students, teachers, and members of the public and private sectors. A summer institute utilizing the *Coral Sea* and other NMRIP facilities will also be developed.

A Network of Regional Innovation Clusters

NMRIP personnel will translate and communicate scientific knowledge for policy and commercial application as part of a national network of dynamic, forward-looking regional innovation clusters. These regional clusters will share best practices with other regions and help resolve resource issues through innovative technologies, new policies and flexible, learning-based economic development. The result of these collaborations and synergies will be a powerful innovation multiplier effect.

The North Coast region is focused on developing a diverse economy that preserves its reputation as an innovation leader, maintaining its reputation through continual improvements in technology.

Leading the World through Smart Partnerships

In partnerships such as NMRIP, all parties benefit from each other's infrastructure: industry benefits from research and the university's ability to approach problems from angles unencumbered by commercial concerns, and universities benefit by having real problems for their students and faculty to investigate—problems whose solution can generate substantial economic and social benefit for the region, nation and world.

These smart partnerships help us use our valuable resources in ways that leverage and multiply their individual strengths. With NMRIP and similar innovation clusters, the whole is indeed greater than the sum of the parts.

Partnering Regionally to Achieve National Goals

NMRIP represents a regional collaboration of several entities:

- HBHCRD and HSU
- Humboldt Bay Municipal Water District
- Educational institutions (PK-20)
- Local, regional and tribal governments
- Natural resource and planning agencies
- Multiple private and nonprofit partners

An NMRIP Advisory Committee will provide direction and leadership to manage cross-sector partnerships and set strategic directions. The Committee will comprise members from regional business, education, social and economic development organizations committed to sustaining the economic, social and environmental vitality of the region.

Effective collaboration between partners to ensure long-term success of the initiative will require a range of coordinated activities:

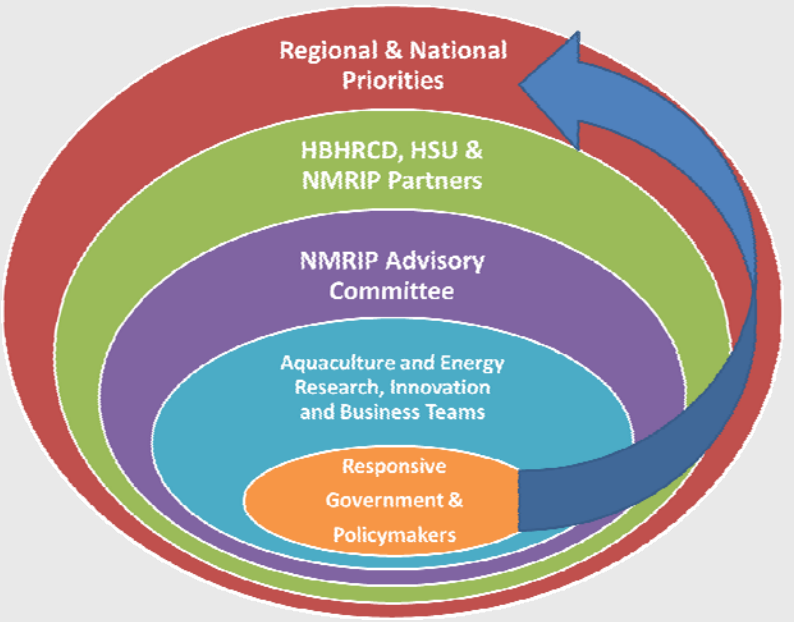
- development of grant and contract agreements for research, training and education opportunities,
- forging of public/private partnerships and community-based partnerships,
- shared facilities for research, instruction, extended education, grant-related use, internships and projects for undergraduate and graduate students, and
- collaboration between the HBHCRD and HSU faculty and staff across a variety of academic disciplines.

Both the HBHRCD and HSU are committed to providing the staff resources needed to make the NMRIP initiative successful and establish NMRIP as a national leader in university-government-industry partnerships.

HBHRCD's and HSU's strong ties to regional business, economic and education organizations will help forge a regional commitment to building and sustaining NMRIP long into the future.

U.S. Economic Development Administration Investment Priorities

- ◊ **Collaborative Regional Innovation**
- ◊ **Public/Private Partnerships**
- ◊ **National Strategic Priorities**
- ◊ **Global Competitiveness**
- ◊ **Environmentally-Sustainable Development**
- ◊ **Serving Economically Distressed & Underserved Communities**



NMRIP Collaborative Relationships

Guided by regional and national priorities and developed in collaboration with key stakeholders, NMRIP's research will help develop business and technology innovations that influence policy-making, change markets, and create a more secure food and energy future for the nation.

NMRIP—Assets on Land and Sea

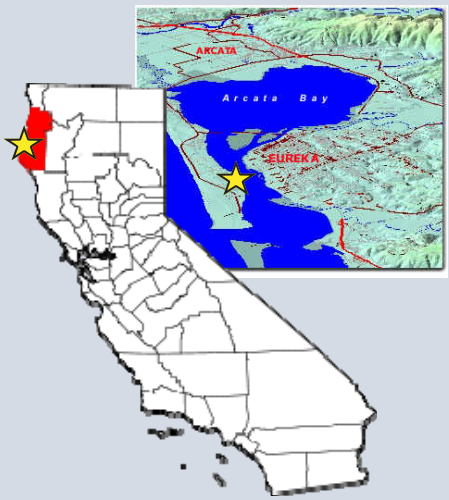
The NMRIP site will utilize re-vitalized and re-purposed industrial infrastructure to diversify the economy of the Humboldt Bay region.

NMRIP is designed to serve as an innovation-driven facility with the following areas of focus:

- Sustainable aquaculture research and production of both shellfish and finfish for local consumption and export.
- Renewable energy research and power production from a variety of wave, offshore wind, and osmotic power projects.
- Regional goods transportation and shipping through an improved public shipping dock and bulk storage facilities.

The Site

The NMRIP site, on the Samoa Spit between Humboldt Bay and the Pacific Ocean, provides unique and critical natural resources and immediate opportunities for industrial operations on a medium to large scale. The mill's outfall pipeline—a 48-inch pipe extending 1.5 miles offshore to a depth of 150 feet—is a major resource that can be retrofitted to serve additional functions: as a seawater intake from the Pacific Ocean, and as a conduit for power lines from offshore wind and wave technologies and fiber-optic cable.



Key

Aquaculture

A—Fish raceways for finfish production

B—Aquaculture/mariculture hatchery

C—Aquaponics greenhouse

D—Shellfish rafts for oyster cultivation

E—Filter for water treatment

F—Fresh water from the water district

G—Water clarifiers to remove minerals

Energy Research and Production

H—Fabrication for energy systems

I—Renewable energy research labs

J—PRO (Pressure Retarded Osmosis) Energy

K—Biomass storage (logs, chips, pellets)

L—20 MW biomass boiler

M—Wind and wave energy assembly area

N—60 kV transmission lines

Marine Research a

O—Classrooms

P—Visitor Center

Q—Labs

R—Research vesse

S—Marine research

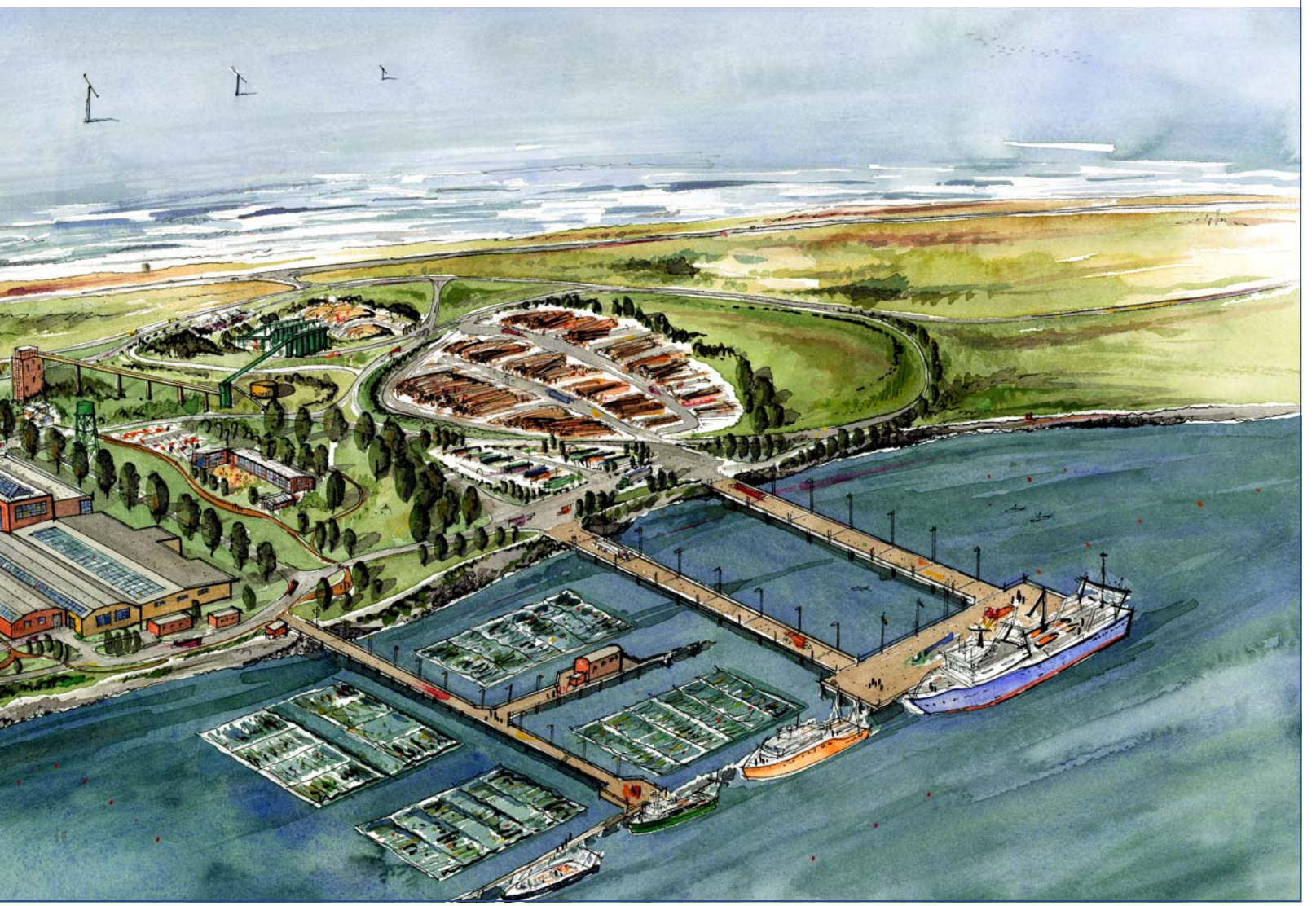
Shipping and Bulk

T—Public shipping

U—Longshore serv

V—Bulk storage wa

W—Bulk transfer fr



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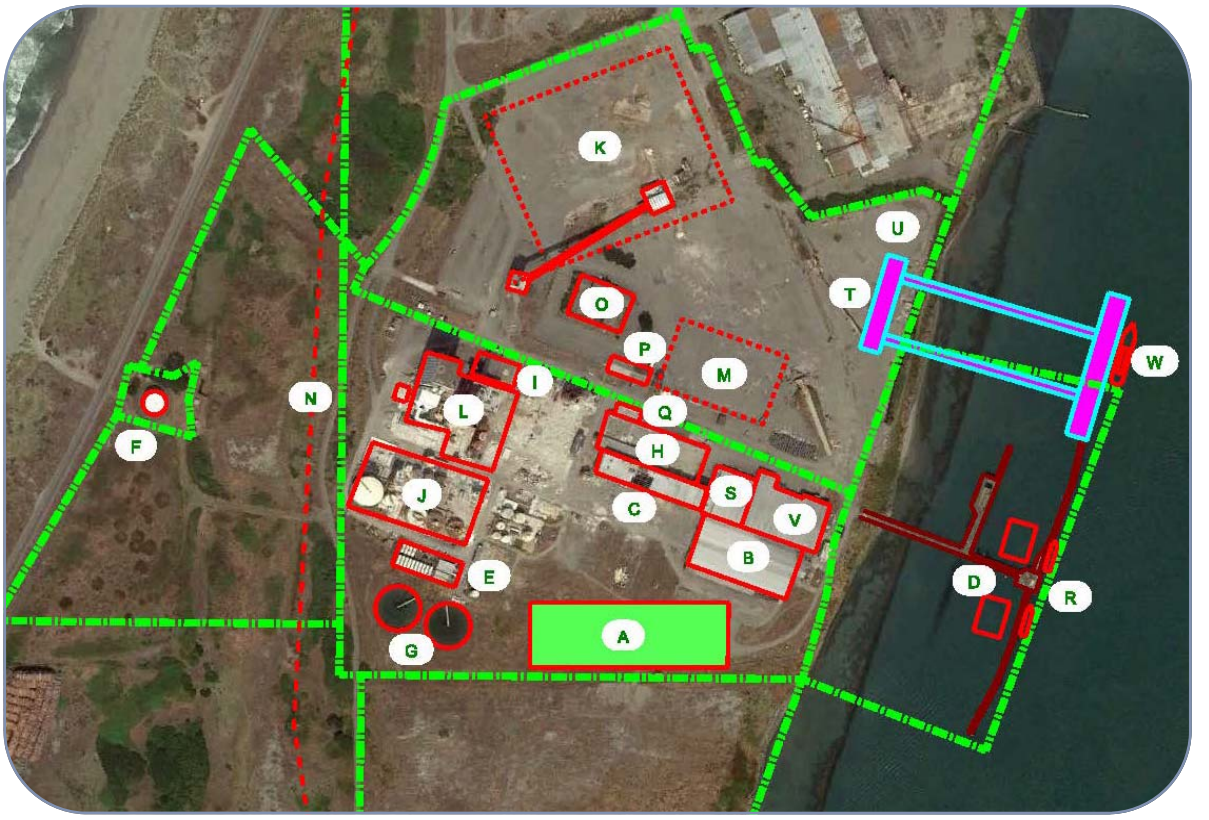


AQUACULTURE

SECURING OUR NATION'S FOOD

Aquaculture research and development at NMRIP will play an important part in improving our national food security. A variety of aquaculture activities will be developed at NMRIP, including shellfish, finfish, algae, and aquaponics.

Currently, about 90 percent of domestic seafood consumption is met through imports, a trend that is expected to worsen as competition for vital food resources intensifies in the years ahead.

As demand for seafood is increasing, nations around the world are turning to aquaculture to fill the gap.The domestic aquaculture industry has the potential to provide high-quality seafood and relieve pressure on wild fisheries and reduce dependence on imports.

Research at NMRIP will increase food availability through research on sustainable land- and sea-based aquaculture products. This research will identify strategies to decrease the number of food insecure individuals, families, and communities in the region, nation and across the world.

The domestic aquaculture industry has the potential to provide high-quality seafood and relieve pressure on wild fisheries. As demand for seafood is increasing, nations around the world are turning to aquaculture production to fill the gap.

NMRIP will help develop a globally competitive and diverse aquaculture sector in the United States, meeting the demand for high-quality and affordable seafood that is produced safely, that protects the environment, and that provides opportunities for economic growth.

Aquaculture activities at NMRIP will create significant economic development and employment opportunities for Humboldt County and demonstrate a path forward for other coastal regions.

SHELLFISH: OYSTER AND CLAMS

Humboldt Bay has long been one of California's most productive shellfish culturing locations. With guidance from the NOAA's National Shellfish Initiative, Humboldt Bay's Aquaculture Expansion Project is providing increased opportunities for culture of oysters on state trust tideland.

Over the last several years, a severe shortage of oyster seed among shellfish growers in Canada, Washington, Oregon and California has provided an excellent opportunity for NMRIP to fill the void, for both domestic users and for export.

Ocean acidification has played a part in the significant decline in oyster seed production. Shellfish growers have responded to this shortage through innovation and increasing hatchery capacity at the Natural Energy Laboratory of Hawaii Authority (NELHA) in Hawaii and other west coast sites, including a planned hatchery for Humboldt Bay.

A major innovation to increasing seed production efficiency has been the use of Floating Upwell System (FLUPSY) rafts and co-locating these floating shellfish nurseries in traditional industrial locations—in shallow water that does not conflict with commercial shipping. The ship berthing dock area at NMRIP will provide an ideal location for local and out of state shellfish growers to establish and expand their industry.

Photos of Freshwater Tissue Pulp Mill facility in operation. The mill closed in 2008. ***Source: Freshwater Mill Archives***

Oyster production in Humboldt Bay using Floating Upwell System (FLUPSY) rafts, with the NMRIP site in the background. ***Source: Aqua Terra Associates.***

Macroalgae (Seaweed)

Humboldt Bay is home to several native species of seaweed that could be developed for human and animal food, nutraceutical, pharmacological, and many other purposes. Macroalgae can be grown in wastewater from recirculating finfish culture systems and the proposed shellfish hatchery at NMRIP. This process will also help remove nutrients and impurities before discharge through the ocean outfall line.

National Aquaculture R&D Strategic Plan

NMRIP's goals are well-aligned with the National Aquaculture Research and Development Strategic Plan and its nine identified strategic goals:

1. Advance Integration of Aquaculture Development and Environmental Conservation
2. Employ Genetics to Increase Productivity and Protect Natural Populations
3. Improve Aquatic Animal Health
4. Improve Production Efficiency and Well-being
5. Improve Nutrition and Develop Novel Feeds
6. Increase Supply of Nutritious, Safe, High-quality Seafood
7. Introduce Innovative Production Systems
8. Create Skilled Workforce and Effective Technology Transfer
9. Integrate Economic and Social Sciences

Microalgae

Microalgae research holds high commercial promise. Products can be developed from the over 30,000 known freshwater and marine species in areas including nutraceuticals, pharmaceuticals, natural animal feed additives, cosmetics, organic pesticides, and environmental remediation.

For biofuel production, microalgae has produced oil yields as high as 1,000–4,000 gallons per acre per year. The extraction of carbohydrates and proteins from microalgae is equally valuable for human and animal nutrition, and an important substitute to the dwindling supply of fishmeal and fish oil for aquaculture feeds.

Aquaponics

Aquaponics—growing fish and plants together in land-based systems—is one of the fastest growing segments of the aquaculture industry. In such systems, waste from the fish provides nutrients for the plants, and the plants recondition and clean the water for recirculation back to the fish.

NMRIP is well suited for development of an aquaponics system on a commercial scale. Such a development will offer high productivity with minimal space requirements, low environmental impacts, and the ability to grow crops out of season and close to local markets, all with minimal nutrient input and pest control requirements.

Lettuce production in an aquaponics facility. ***Source: Aqua Terra Associates.***

DEVELOPING RENEWABLE ENERGY RESOURCES

Humboldt County and the North Coast of California have abundant renewable energy resources. NMRIP will support research and innovation activities in several renewable energy technologies, including biomass energy conversion, offshore wave and wind power, and osmotic power. Research at NMRIP will address the potential of these resources to meet local demand, to reduce power requirements of other industrial processes (e.g., wastewater treatment, desalination), and to transmit power outside the region.

NMRIP's energy research and development activities will be integrated with the aquaculture research using principles of industrial ecology. Use of the boiler at the site for biomass energy conversion can provide residual heat for on-site heating needs (water heating, indoor climate control, dehydration, etc.), and emissions from the boiler can provide carbon dioxide for the microalgae facility, among other synergies.

Biomass Energy Conversion

HSU's Schatz Energy Research Center (SERC) and the Department of Forestry are researching the recovery of forest residues from commercial harvest, wildland fire hazard fuel reduction, and forest restoration. Mobile biomass conversion technologies (MBCTs) could reduce these residues in mass and volume through gasification (with biochar as its product), pyrolysis (producing torrefied pellets), and densification (creating briquettes).

Biomass gasification research at HSU's Schatz Energy Research Center. ***Source: HSU***

Commercialization of MBCTs can help reduce our nation's dependence on fossil fuels, reduce greenhouse gas emissions, improve the economics of forest management activities, create employment in the forest and energy sectors, and support economic development in rural areas.

SERC is recognized internationally for its research in renewable energy, and its emphasis on regional energy planning and development. SERC's research in areas of biomass, wave and wind, and osmotic power will play a guiding role at NMRIP.

Offshore Wind & Wave Power

The offshore wind resource near NMRIP is among the best in the world. Several wind developers have expressed interest in developing wind farms with floating or moored turbines from 3 to 12 miles offshore. The confluence of the electric grid, a strong wind resource, and the deepwater port for turbine servicing makes the site an ideal location for wind development.

The offshore wind resource near NMRIP is among the best in the world.

The same holds for wave energy. The wave resource is substantial, and power companies are conducting exploratory research and planning efforts for large-scale wave-energy demonstration projects.

Currently, wave energy technologies are relatively immature, even with the tremendous energy potential worldwide and great interest in the technology. In fact, wave energy potential offshore from NMRIP could be as high as 1,000 MW. Research at NMRIP will help guide development of this resource in economically and environmentally sound ways.

Osmotic Power

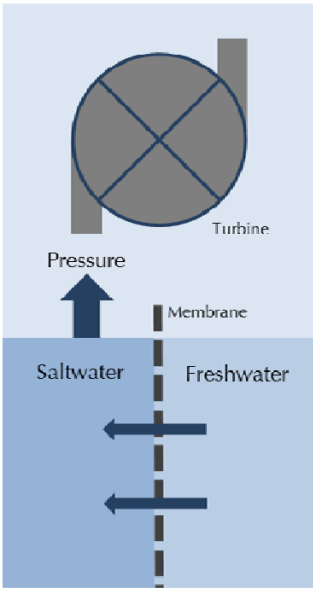
NMRIP is also uniquely situated for research and development of pressure retarded osmosis (PRO) technologies. The energy released from the mixing of freshwater with saltwater is a source of renewable energy that can be harvested. In PRO, water

Offshore wind turbines for power generation are anchored to the sea floor. The turbines pictured are developed by Nautica Wind Power.

from a low salinity solution permeates through a membrane into a pressurized, high-salinity solution; power is obtained by depressurizing the "permeate" through a hydroturbine. The large volumes of both salt and fresh water at the NMRIP site make it an ideal place to research and pilot the development of PRO power facilities.

The combination of increased interest in renewable and sustainable sources of power production and recent progress in membrane science has led to greater interest in PRO in the last decade.

Among the many potential benefits of PRO technology is its ability to greatly reduce the power required for desalination and wastewater treatment, both issues emerging as critical considerations in an increasingly crowded world with emerging water scarcities.



Osmotic Power Generation

Osmotic power generation is based on the principle of osmosis—the tendency of molecules of a solvent to pass through a semipermeable membrane from a less concentrated solution to a more concentrated solution. In the diagram, freshwater and saltwater are divided by a membrane. The freshwater is drawn towards the saltwater, which creates pressure that can be used to drive a turbine and produce electricity.

Students in Humboldt State University's Environmental Resources Engineering (ERE) department conduct laboratory research on osmosis technology.
Source: HSU

FUNDING FOR IMPLEMENTATION AND SUSTAINABILITY

While federal and other forms of government support are critical to secure resources and fund research, development, demonstration and commercialization activities at NMRIP, the facility will also leverage other forms of public and private funds as it progressively moves toward greater reliance on the private sector. As shown below, the long-term funding plan for NMRIP involves reducing federal funding over time as innovations from NMRIP's key technology areas create new markets and increasingly attract private investment.

The North Coast of California is developing a diverse economy that preserves its reputation as an innovation leader, a reputation maintained through education, research, continual improvements in technology, and market-savvy development of innovative products and services. NMRIP will develop the region's innovation pipeline by strategically combining and developing the region's assets, and by seeding and fertilizing the regional innovation ecosystem with human, natural, physical and financial capital.

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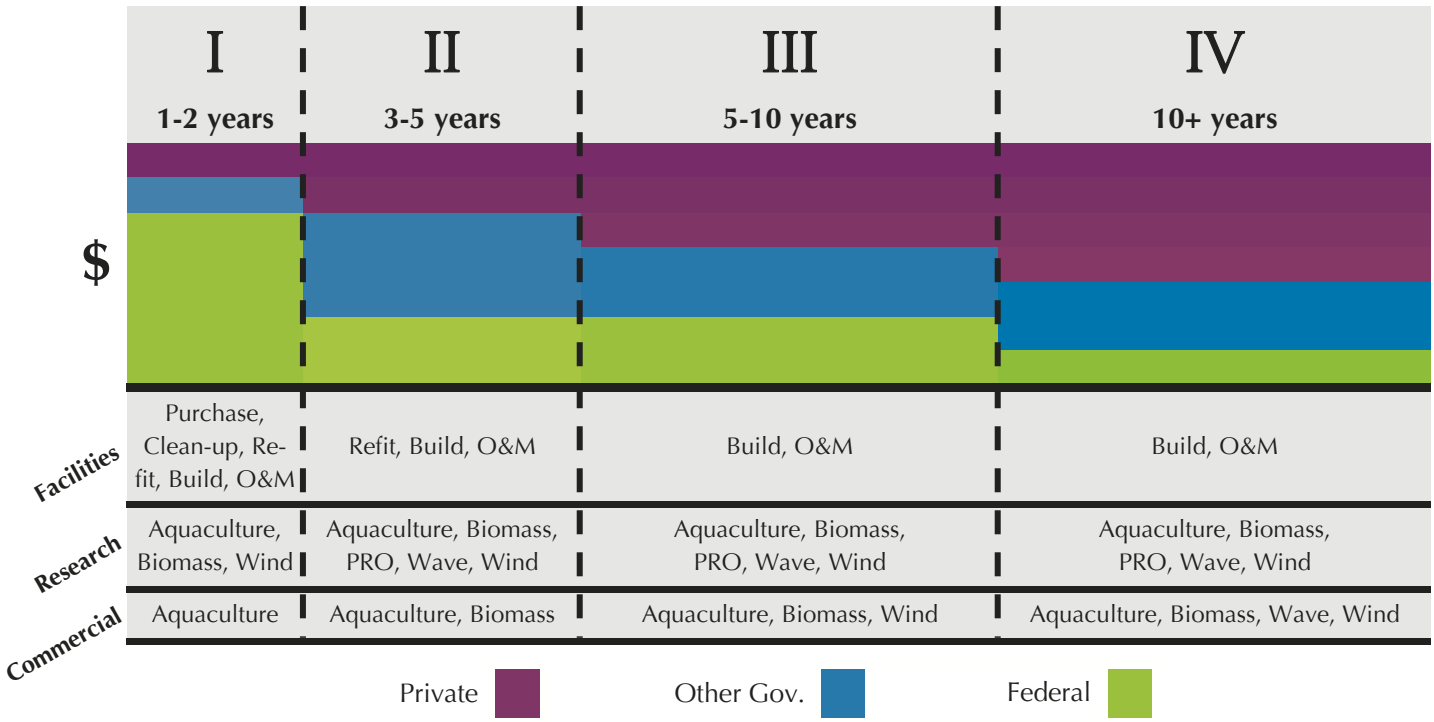
NMRIP Project Funding (relative contribution)



This figure represents a phased approach to implementation of infrastructure, research activities and commercial uses, as well as the relative contribution of private and government funds anticipated to initiate operations and make NMRIP economically sustainable.

For more information:

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