Pacific Northwest
NATIONAL LABORATORY

# Opportunities for the Co-location of Marine Energy and Aquaculture

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U.S. DEPARTMENT OF ENERGY BATTELLE

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# Today's Presentation

- Marine Energy and Aquaculture
  - Background
  - Co-location and examples
- Community-Scale Aquaculture and Marine Energy
  - Partnership with Jamestown S'Klallam Tribe
  - Overview of research – spatial analysis, energy assessment, outreach
- Other projects
  - Offshore aquaculture and wave energy
  - Shellfish and kelp aquaculture and tidal energy


CalWave

# Background

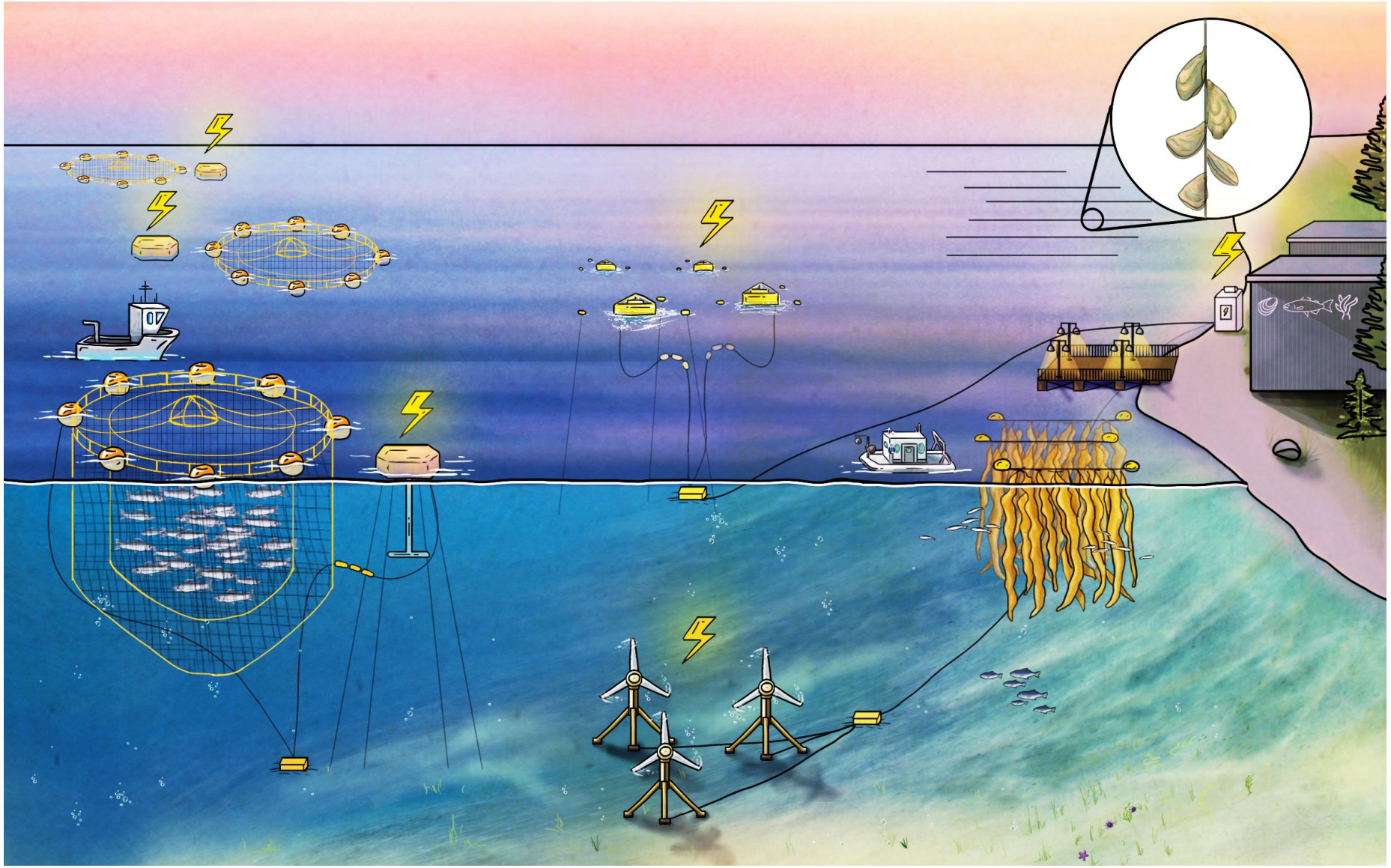
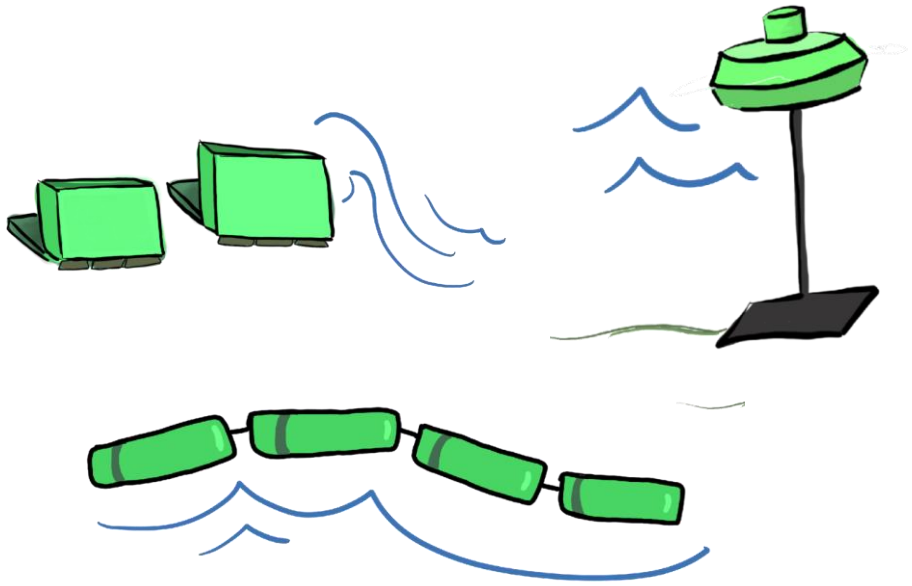
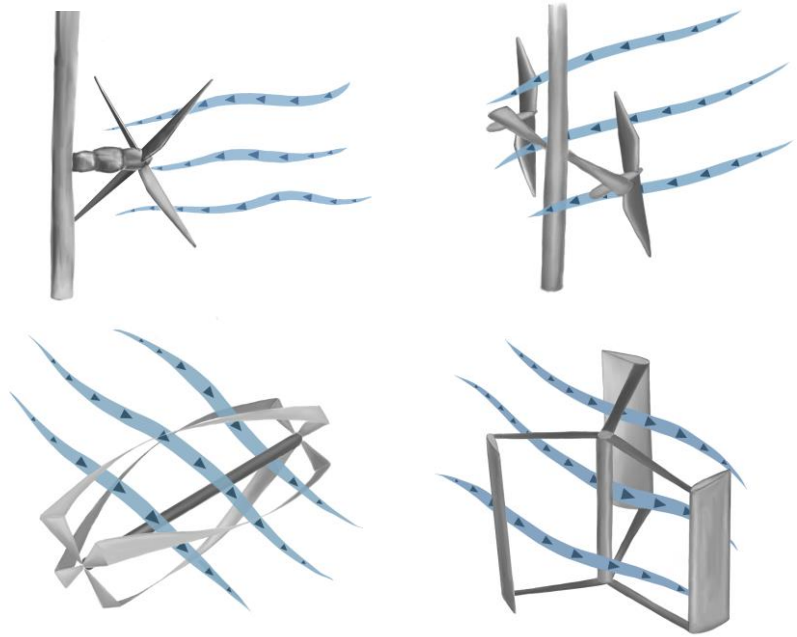


*Illustration by Stephanie King, Pacific Northwest National Laboratory*

# Marine energy is all forms of energy derived directly from the seas and oceans

Marine energy is often divided into ***wave energy*** and ***tidal energy***



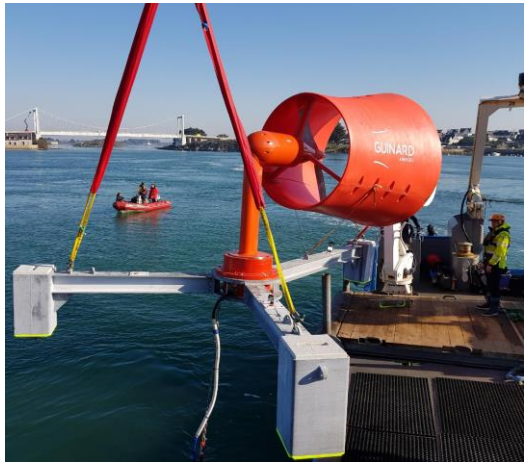


Wave devices capture the motion of the waves through a variety of different movements, like flapping or bobbing in the waves.

The tidal devices pictured above capture energy of flowing water as the tide pushes water from one place to another, creating a current.

# Marine Energy Devices

## Tidal energy devices

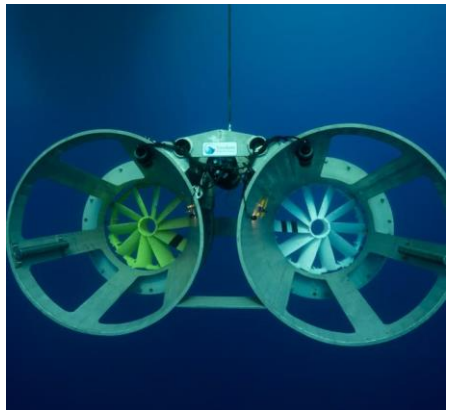



## Wave energy devices



## Ocean thermal energy converter


## Ocean current device



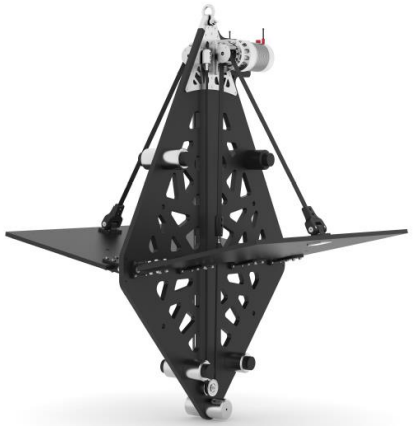
Images courtesy of Andritz, ERSEO project, CalWave, Albatern, AMOG, Makai Ocean Engineering, OceanBased Perpetual Energy

# Co-location of Aquaculture and Marine Energy

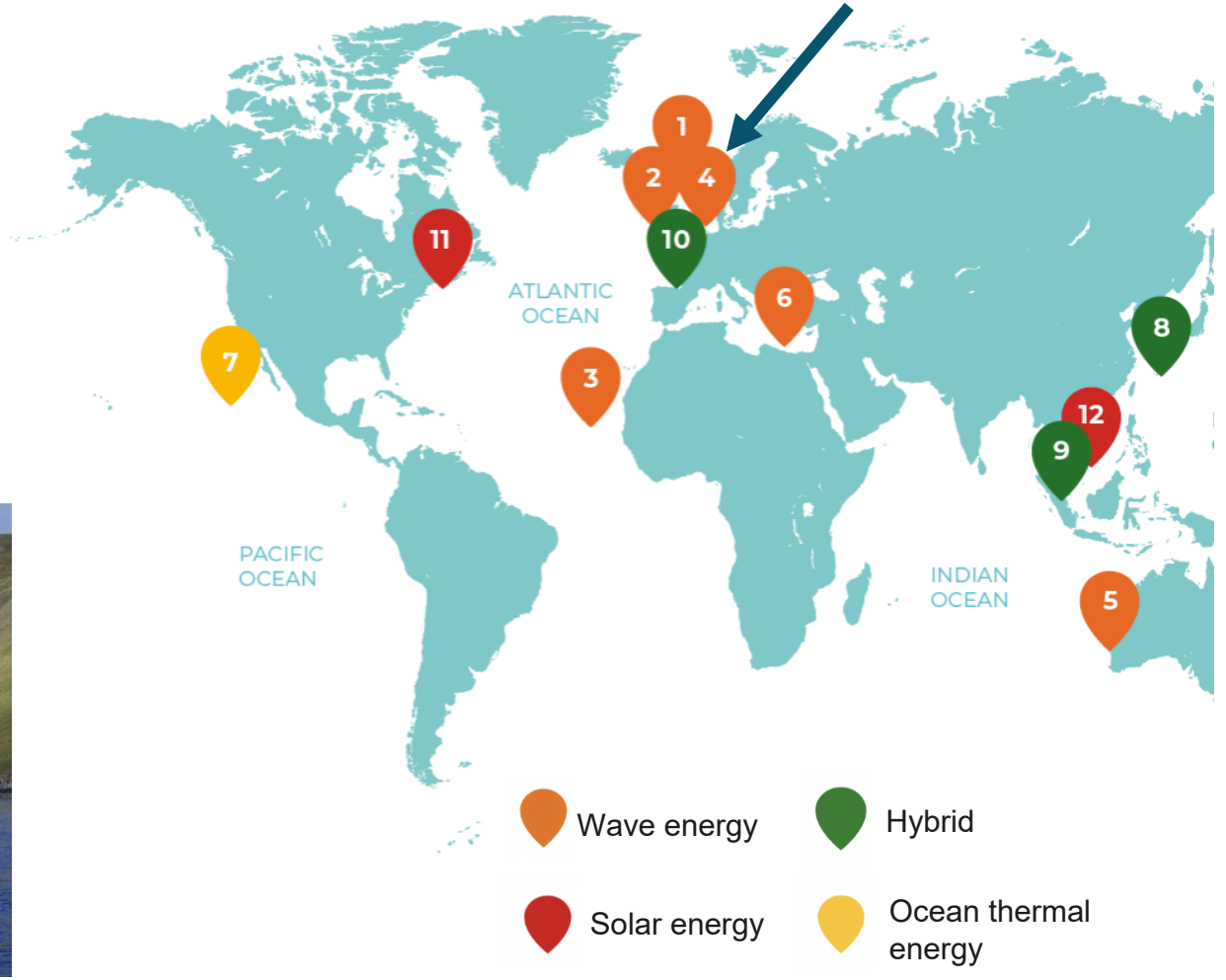
## Example:

*Nearshore salmon aquaculture & wave energy (Scotland)*

- ✔ 4.6 kW wave energy device designed for remote installation
- ✔ Device installed for 18 months, produced 11 MW of power



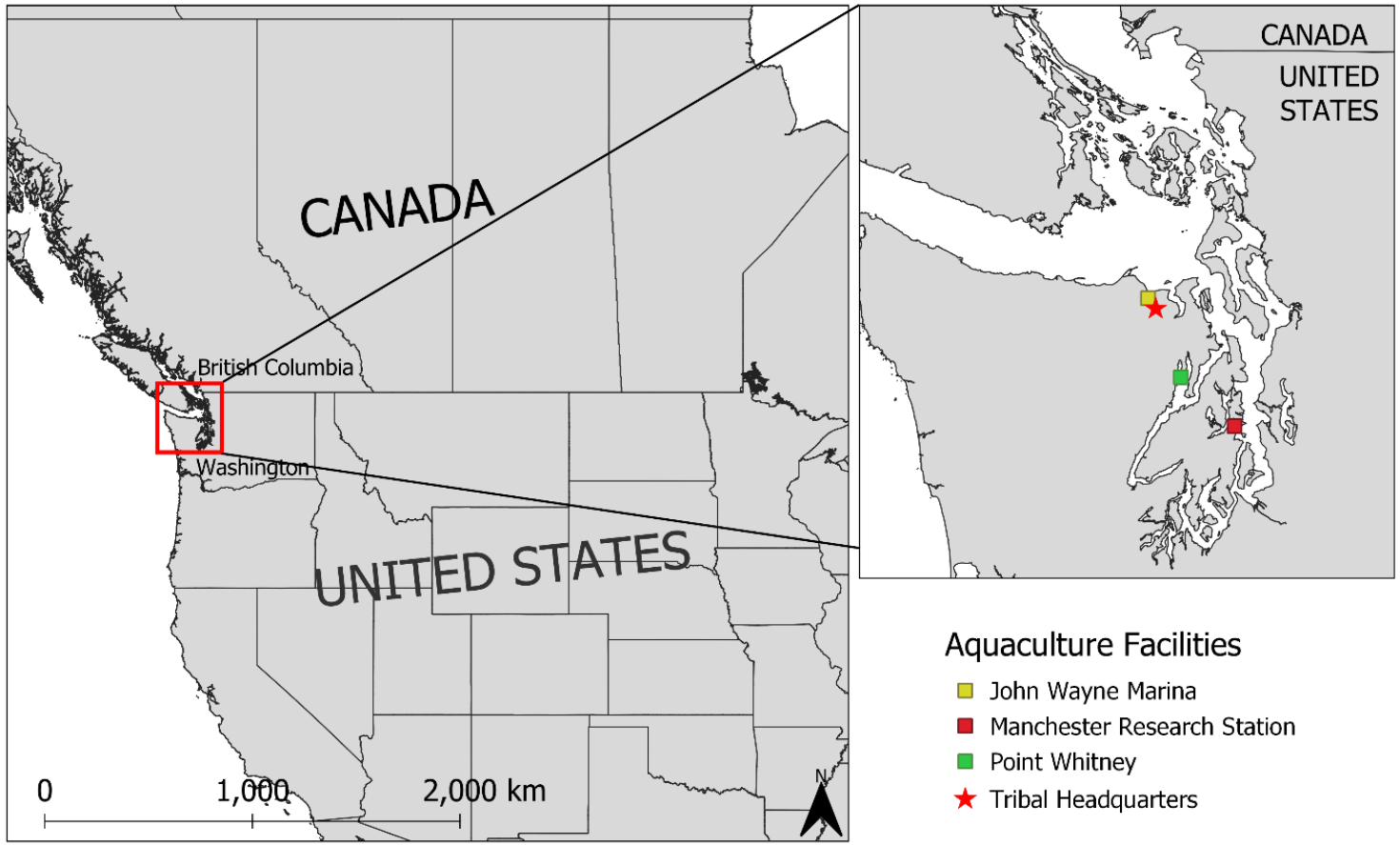
*Images courtesy of Aqua Power Technologies*




Freeman et al. (2022)

# Community-Scale Aquaculture and Marine Energy

- Understand potential to use marine energy (wave and tidal energy) for community-scale aquaculture in the Southern Salish Sea (Washington, US)
- Partner with the Jamestown S'Klallam Tribe (JST) to understand energy usage and needs at their facilities and the marine energy resources nearby



# Community-Scale Aquaculture and Marine Energy
# Jamestown S'Klallam Tribe Partnership

- JST has set a progressive goal of net zero carbon emissions by 2032
- This project meets focus area in the Tribe's carbon neutrality strategy: Making all Tribal-owned buildings and operations energy-efficient or energy neutral

  - Strategy 1: Promote and install energy efficiency design and infrastructure in Tribal facilities so that Tribal facilities use less energy and become more resilient to climate change

  - Strategy 2: Promote, use, and generate clean energy sources

JST Carbon Neutral Plan 2022

# Community-Scale Aquaculture and Marine Energy
## Jamestown S'Klallam Tribe Partnership

Elaine Grinnell

*"Our people want unhindered and unlimited access to their natural resources. Climate change is threatening our lifeways and resources. We must act now to protect and preserve culturally important resources and assets, ensuring continued economic growth, and promoting long-term community vitality."*

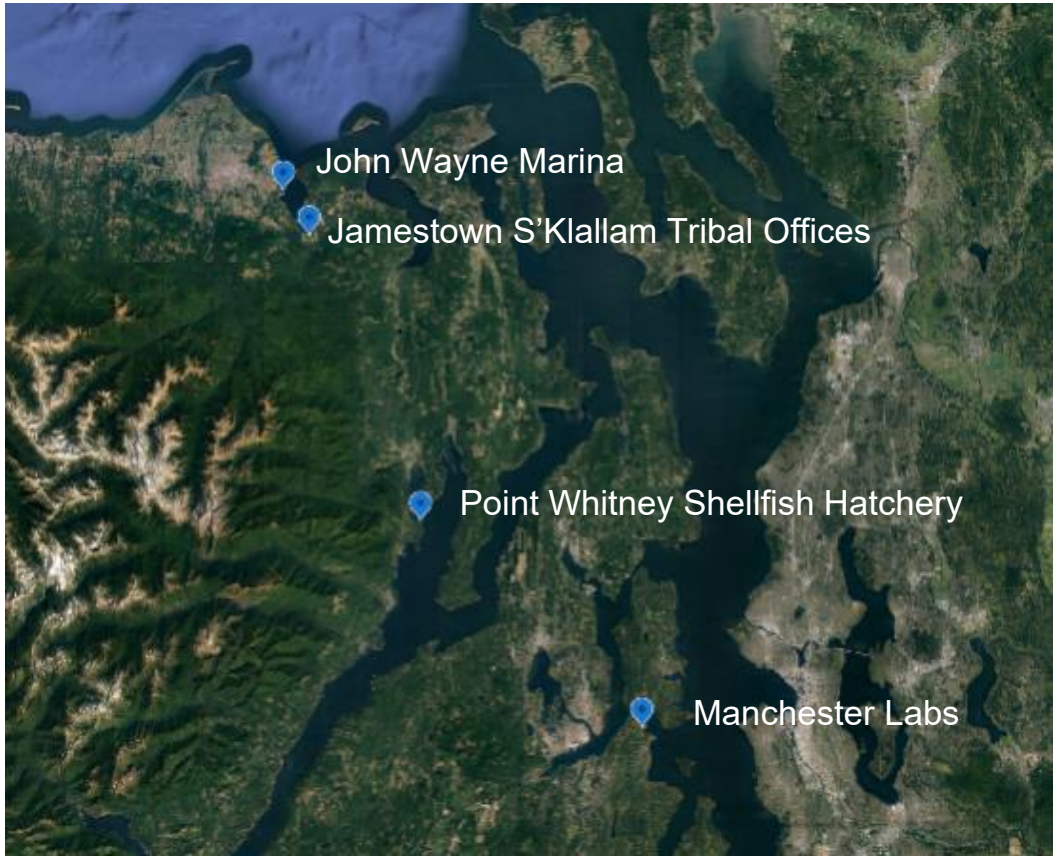
*-From Tribal Climate Camp presentation 2022*

JST Carbon Neutral Plan 2022

# Jamestown S'Klallam Aquaculture Operations

Three JST facilities included in this research:

1. Floating Upweller System (FLUPSY) at John Wayne Marina
2. Point Whitney Shellfish Hatchery
3. Research partnership with NOAA at the Manchester Labs complex



# Research Objectives

## Outreach & Engagement

- Work with JST to develop outreach materials that address identified information needs, concerns, and potential benefits of marine energy and aquaculture

## Energy Assessment

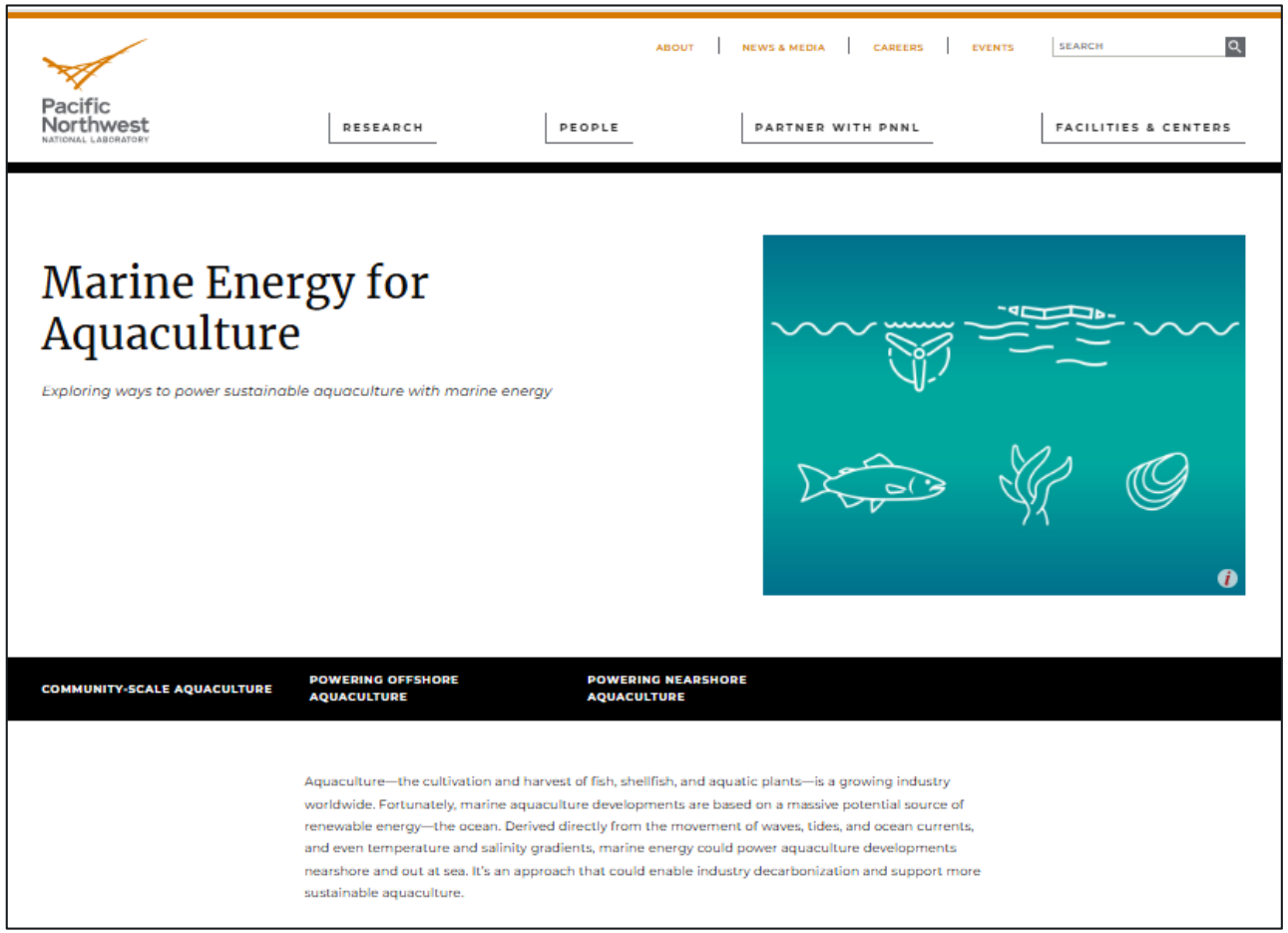
- Conduct a review of systems including seawater pumping and filtering, heating and cooling of water, and algae growing process to understand energy needs

## Spatial Analysis

- Define key parameters and ideal conditions for wave and tidal energy and aquaculture
- Conduct a spatial analysis to find suitable areas for co-location

# Outreach and Education

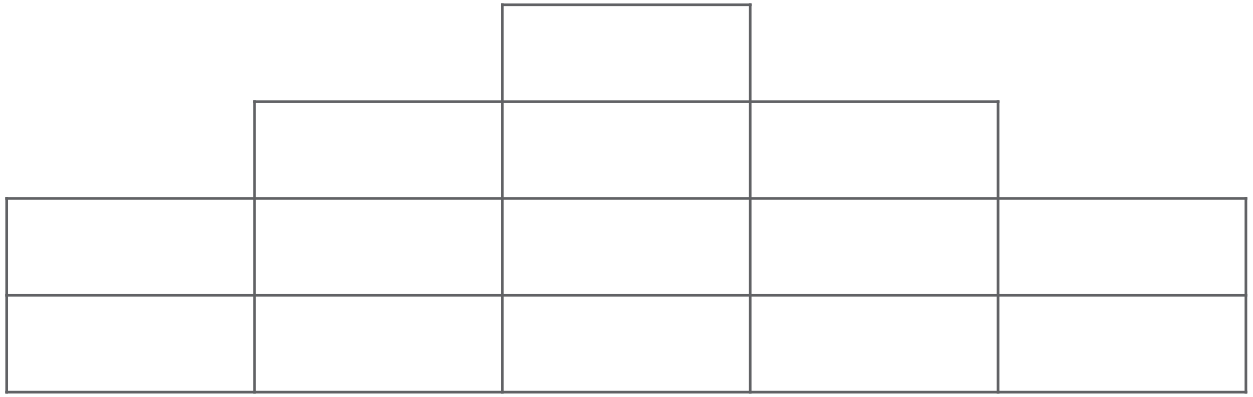
Developing outreach and communication materials that address identified information needs, concerns, and potential benefits of marine energy and aquaculture




# Outreach – seeking your thoughts

We are conducting an online activity to understand what people connected with the aquaculture industry see as the most valuable or beneficial characteristics of energy systems for aquaculture operations. This will help us think about the type and design of marine energy systems that could best serve the industry.

- This activity, called Q sort, involves ranking the benefits from what you consider to be the most to least important in a distribution like the table below
- The ranking and answering a few background questions about yourself will take 20-30 minutes



Least important

Most important

https://app.qmethodsoftware.com/study/12947

# Spatial Analysis

- Assess suitability for co-location by identifying suitable areas for wave and tidal energy and aquaculture in the Southern Salish Sea
- Define parameters and ideal conditions for co-location
  - Based on current research and discussions with JST partners

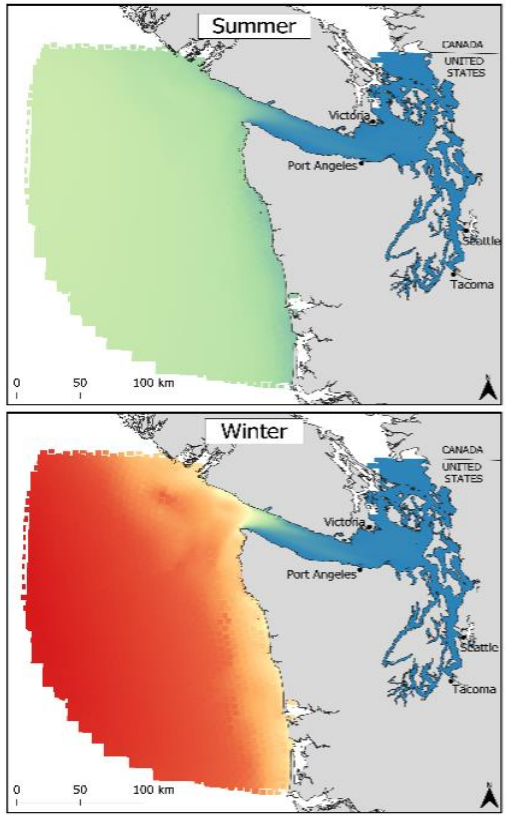
**Parameters for Identifying Suitable Areas for Co-location**

| | |
|---|---|
| Environmental | Wave height, wave power density, tidal current speed, tidal power density, bathymetry, temperature, dissolved oxygen, benthic habitat, shoreline slope stability, forage fish habitat |
| Existing uses | Navigation routes, ports, submarine cables, public beaches |
| Regulatory | Endangered species and critical habitat, marine protected areas |

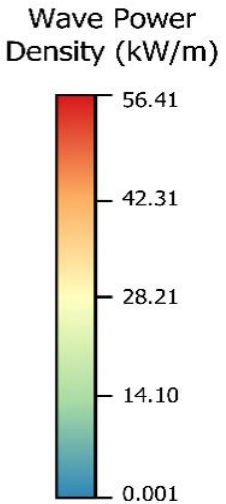
# Spatial Analysis

## Marine energy resource availability

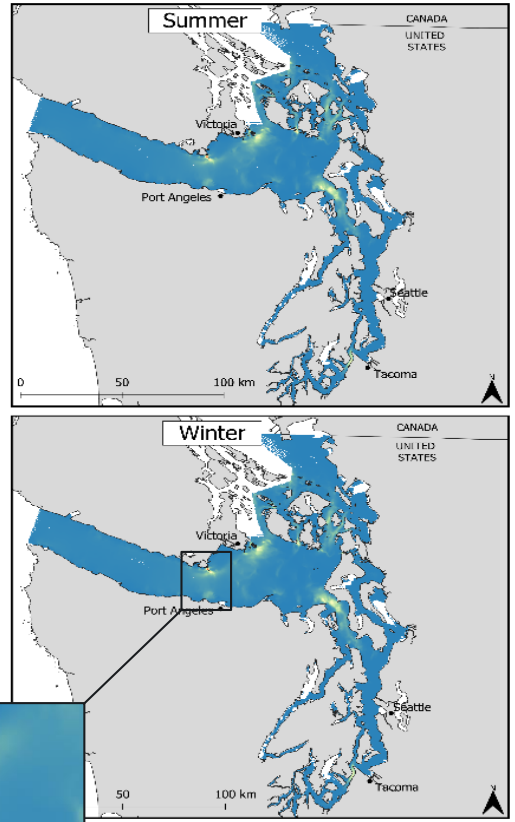
### Wave energy



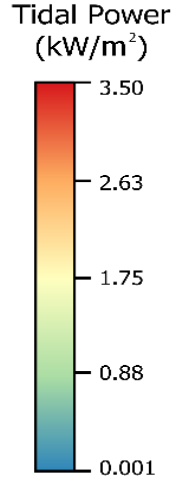

Yang et al. 2019



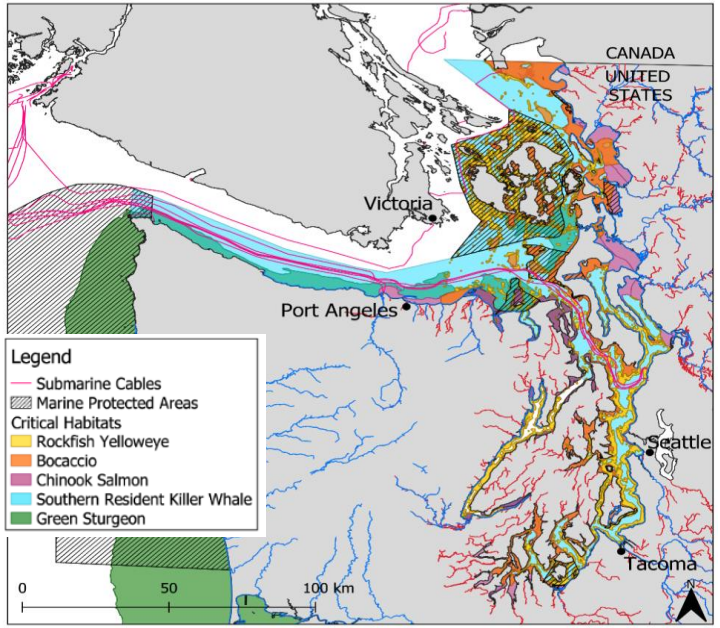

### Tidal energy

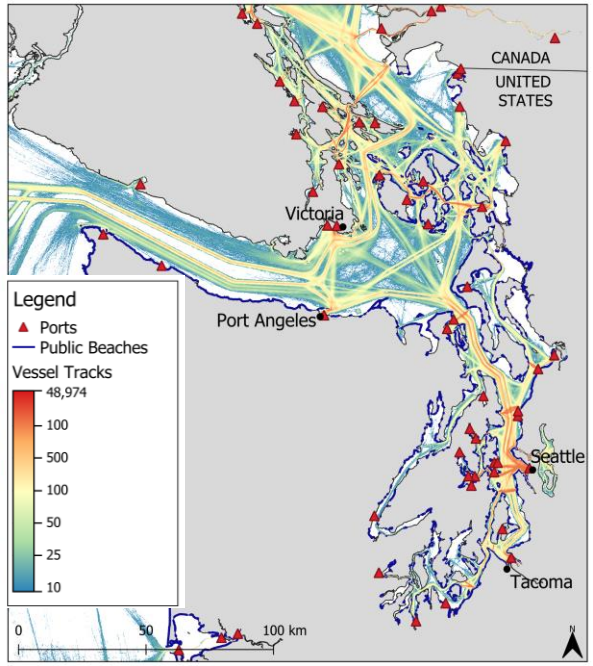



Yang et al. 2021




## Environmental & existing use considerations



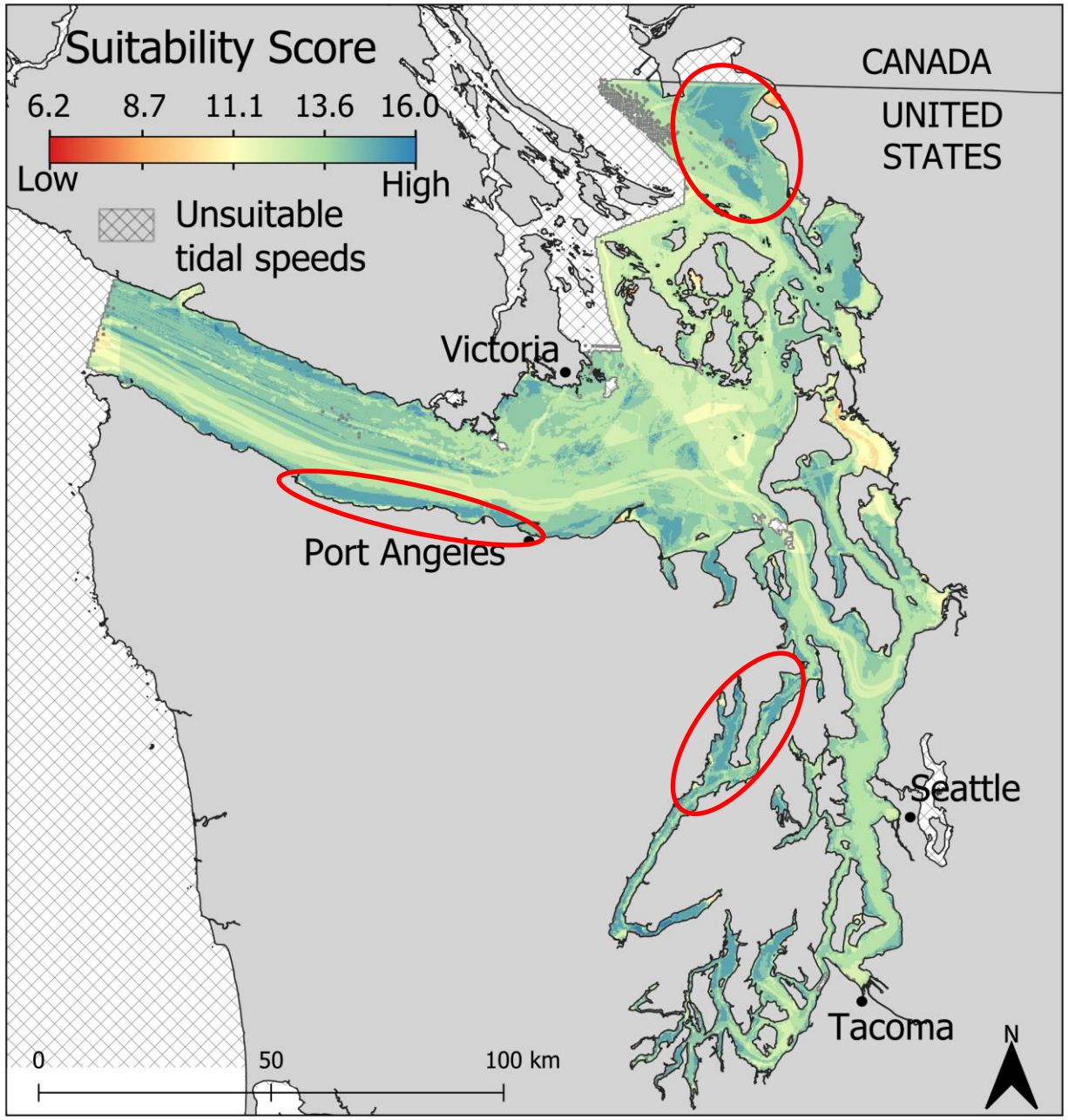



# Spatial Analysis

- Several potentially suitable areas for aquaculture and tidal energy

- Limiting parameters for suitability
  - Critical habitats of marine species
  - Navigation routes
  - Protected areas
  - Underwater cables

**Suitable areas for co-location of aquaculture and tidal energy**



# Energy Assessment

- In-depth review of systems including seawater pumping and filtering, heating and cooling of water, algae growing process, and additional process plug loads

- Identify energy use and potential high-level opportunities for savings

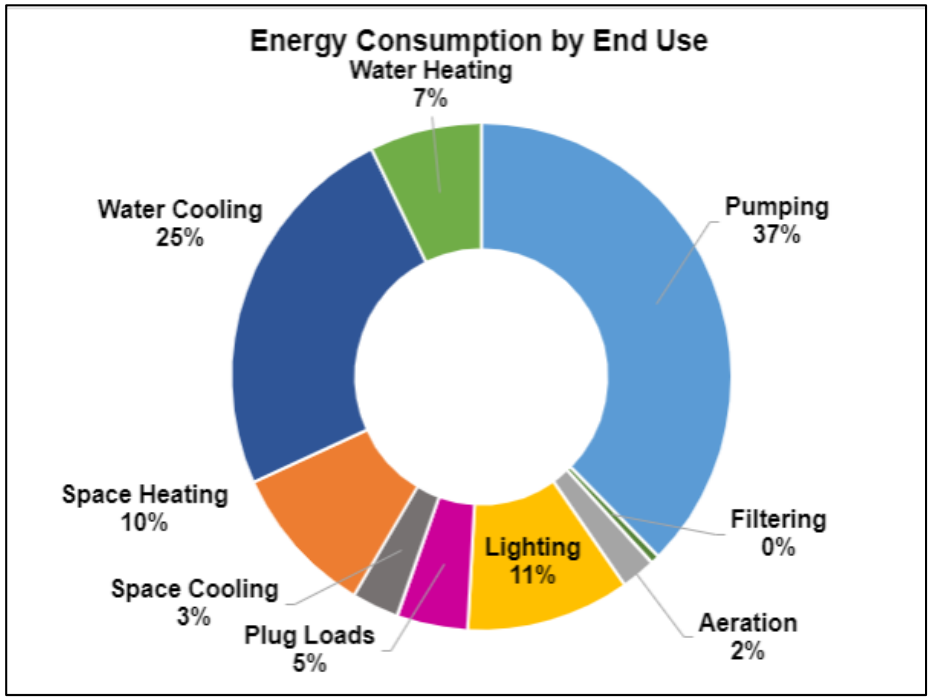

*John Wayne Marina Floating Upweller System (FLUPSY)*

*Manchester Lab Sablefish Net Pens*

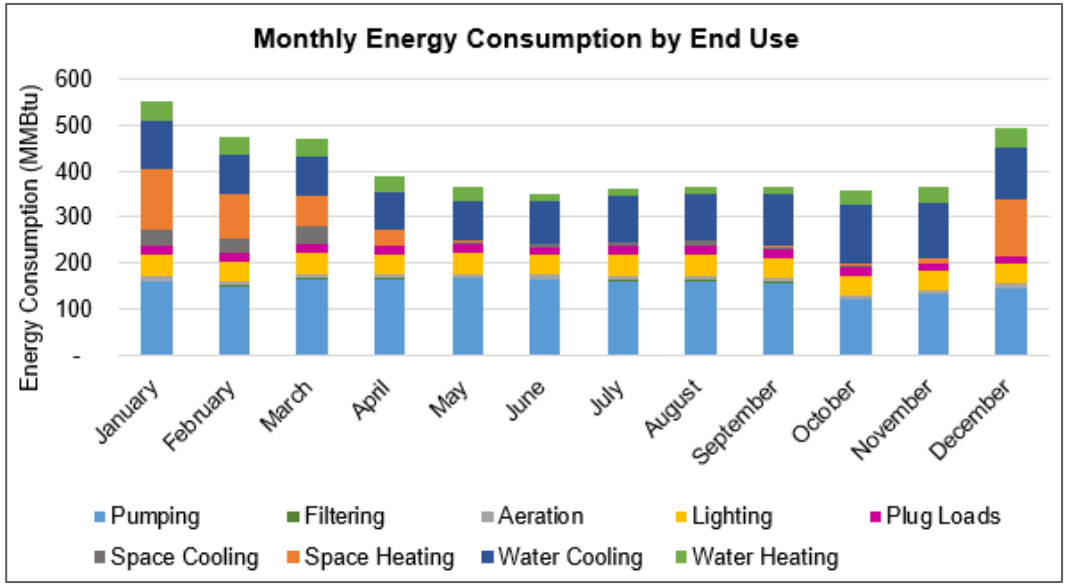
*Point Whitney Algae Tanks*

# Energy Assessment

- Capture the energy needs of JST facilities to help inform the amount of energy being used in aquaculture operations
- Create energy baseline for JST aquaculture operations and compare with marine energy resource potential

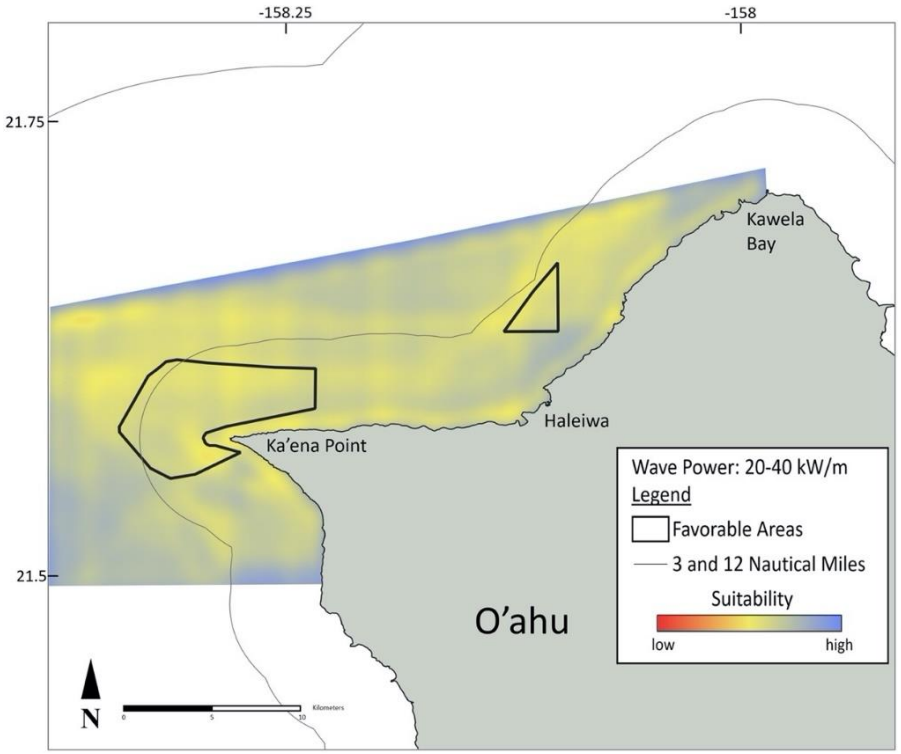


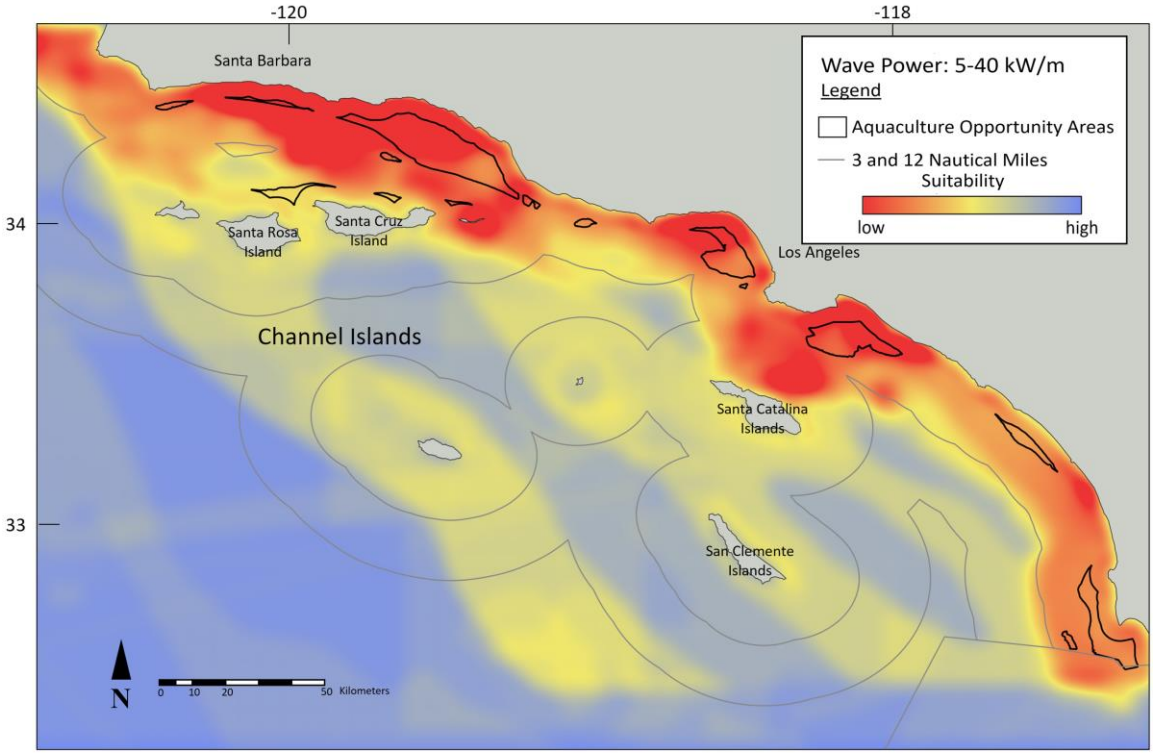

*Estimated total annual and monthly energy consumption by end use for all sites.*



# Other Opportunities for Marine Energy and Aquaculture
## Offshore Aquaculture and Wave Energy

- Assess feasibility to co-locate offshore aquaculture and wave energy off the coast of Hawaii and California
  - Offshore aquaculture energy assessment
  - Regional and local spatial analysis




Garavelli et al. (2022)

# Other Opportunities for Marine Energy and Aquaculture
## Offshore Aquaculture and Wave Energy

- Assess feasibility to co-locate offshore integrated multi-trophic aquaculture (IMTA) with wave energy off the coast of Puerto Rico
  - Spatial analysis
  - Community outreach and engagement
  - Assess wave energy technologies

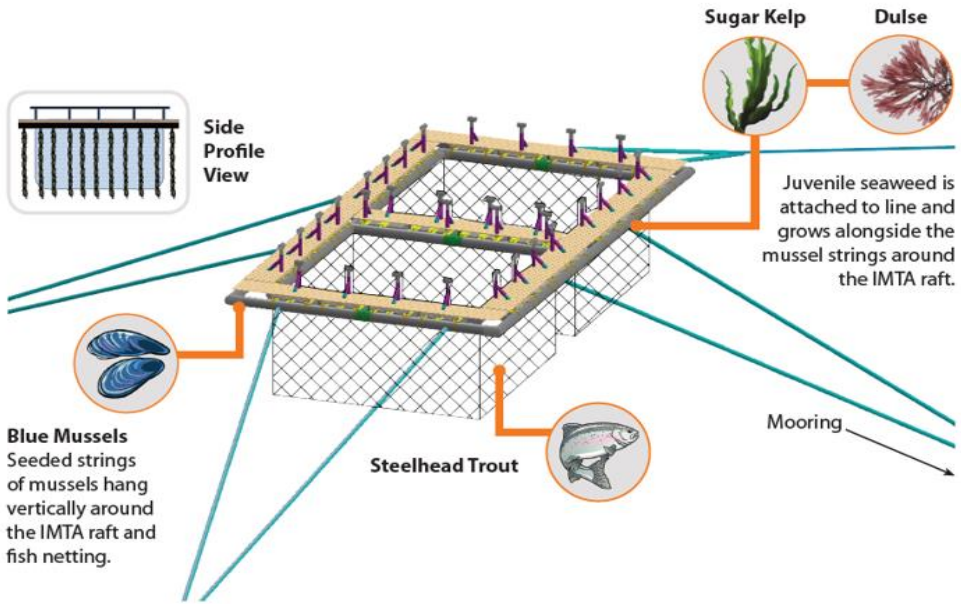
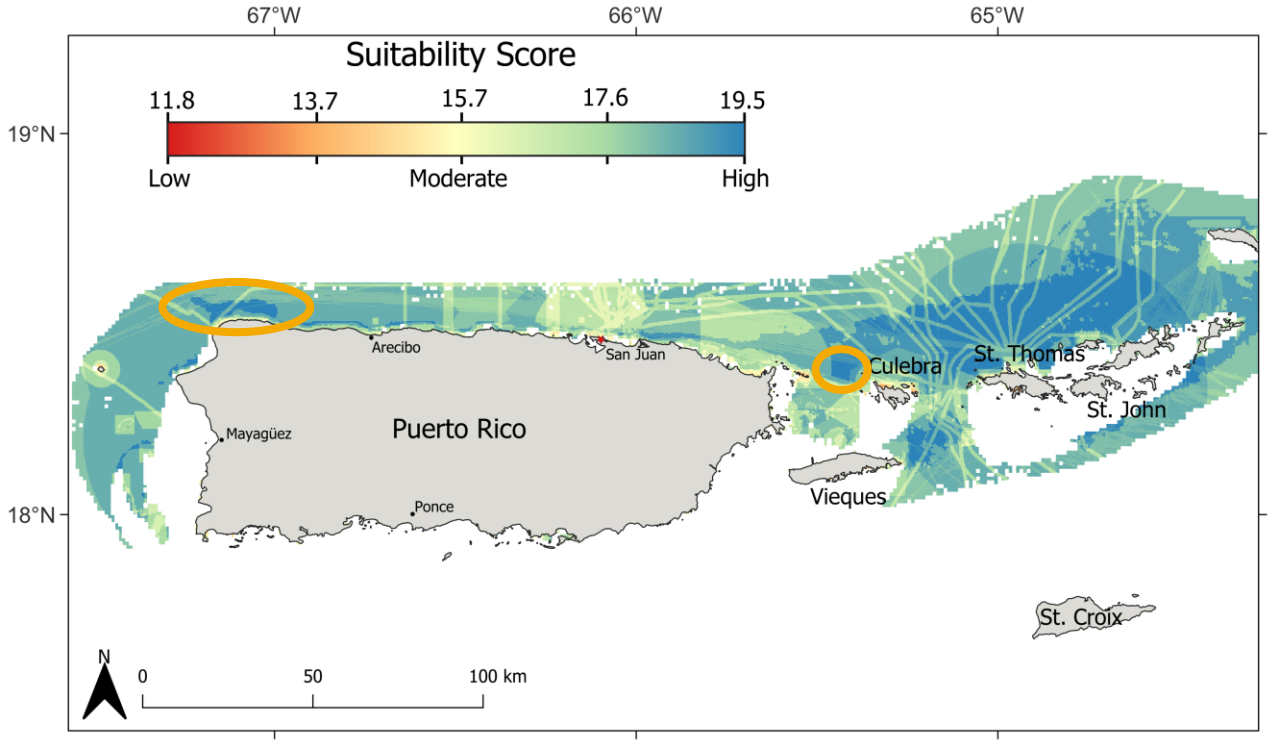



*Image courtesy of University of New Hampshire*



# Other Opportunities for Marine Energy and Aquaculture
## Shellfish and Kelp Aquaculture and Tidal Energy

- Understand potential to use tidal energy for nearshore oyster and kelp aquaculture
  - Tidal could provide energy for pumps, oyster tumblers, etc.
  - Tidal technologies are being developed to produce energy at lower speeds
  - Assess potential in Humboldt Bay, CA

*Tidal device for lower speeds*

*Oyster operation in Humbolt Bay, CA*

# Thank you!

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Special thanks to the U.S. Department of Energy Water Power Technologies Office.



**Q sort activity** via QR code or link below

https://app.qmethodsoftware.com/study/12947

**For more information:**