

Greening Aquarium of the Bay: Recommendations for Reduced Environmental Impact



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Background

Located on San Francisco's Pier 39, Aquarium of the Bay (AOTB) is a non-profit dedicated to the conservation of the San Francisco Bay and its watershed. The 600,000 visitors who come annually view stunning displays of life below the surface in two underwater tunnels and jellyfish, tropical, and other sea life exhibits.

AOTB earned certification as a San Francisco Green Business in 2005. However, this certification only reviewed their business practices, so our project explored the interplay that pumping and chilling have with energy use and animal welfare.



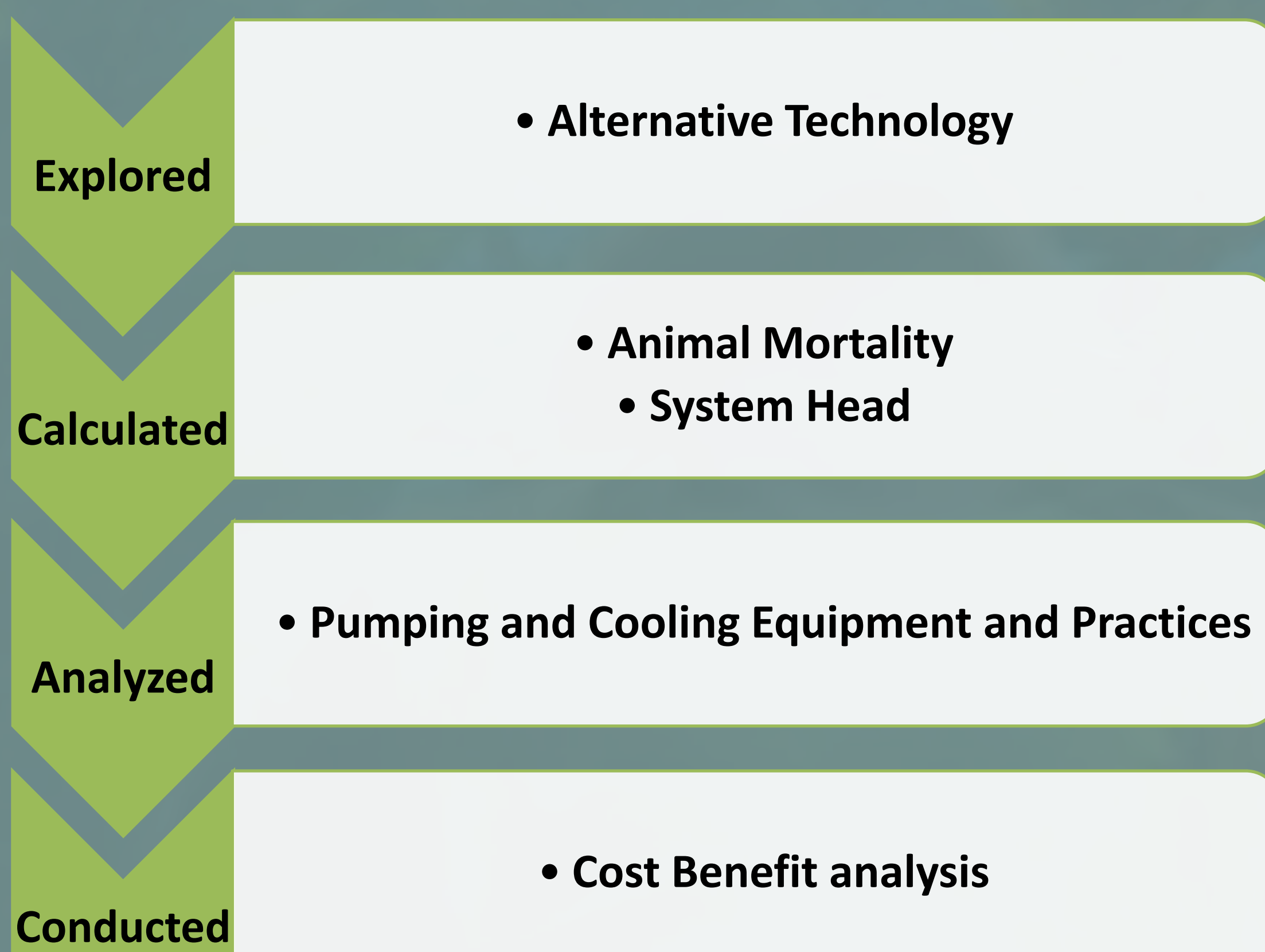
Research Question

How can we improve the Aquarium's environmental performance in a cost-effective way while meeting the needs of the marine animals?

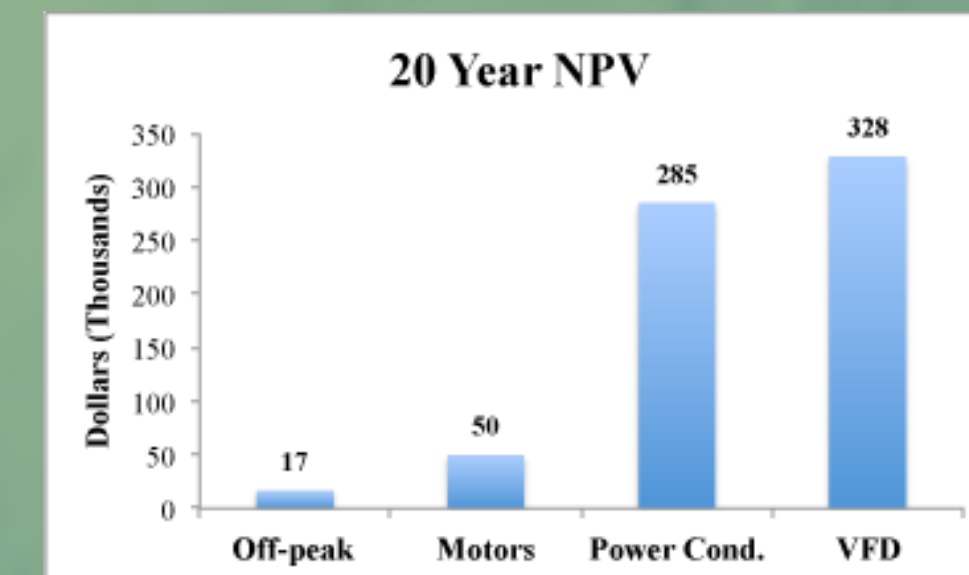
Objectives

- Establish a baseline for energy use, CO₂ emissions, and biological health
- Identify new methods and processes to reduce environmental impacts and improve animal welfare
- Assess economic feasibility of a variety of improvement options

Methods



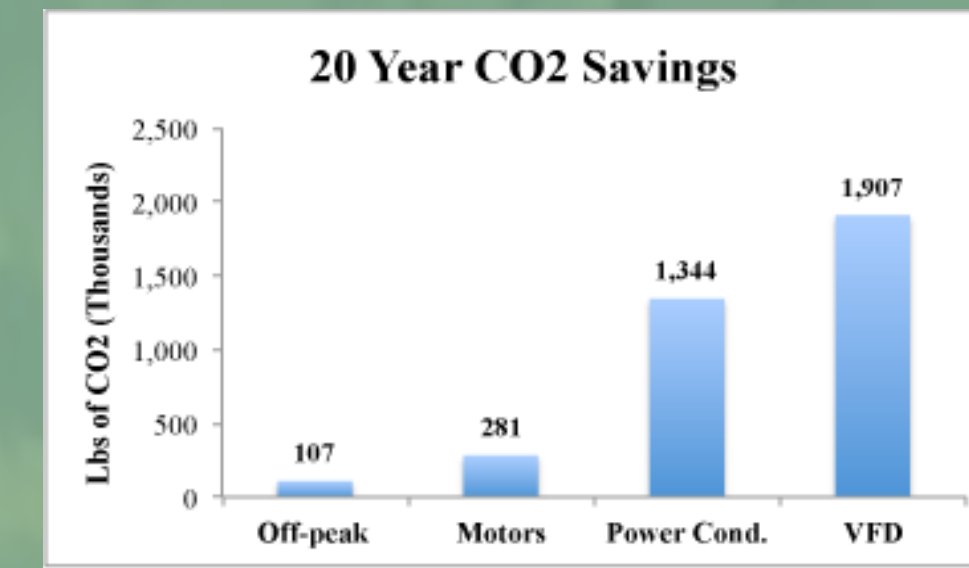
Pumping



Motor replacements: Motors will operate more efficiently when matched to the specified pumping requirements of the system.

Head Reduction: Head can be reduced by replacing the media in the sand filters and replacing the paddle flow meters with magnetic flow meter

Variable Frequency Drives (VFDs): These allow the aquarium engineers to match pumping strength to the head in the system

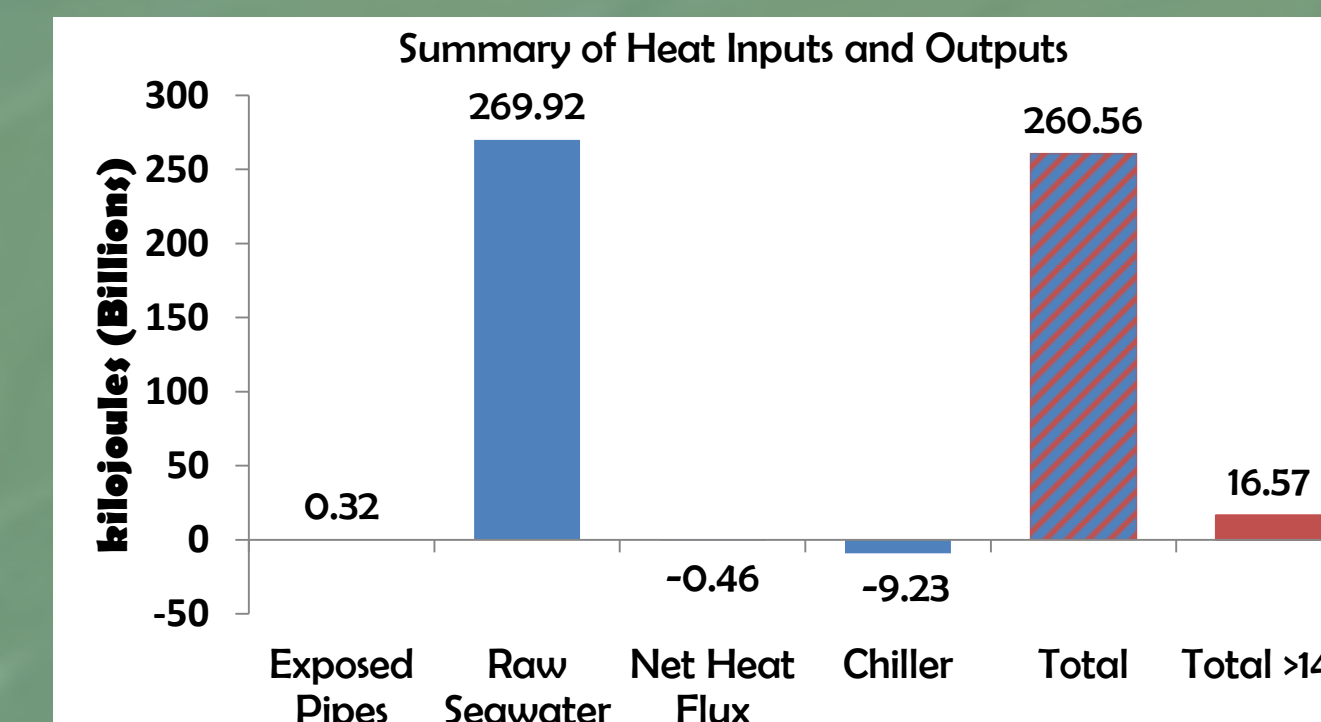


Power Conditioners: improve efficiency by correcting a motor's power factor

Demand Response Plan (DRP): Electricity is less expensive and carbon intensive during hours of the day when demand is low

Results

Temperature Control

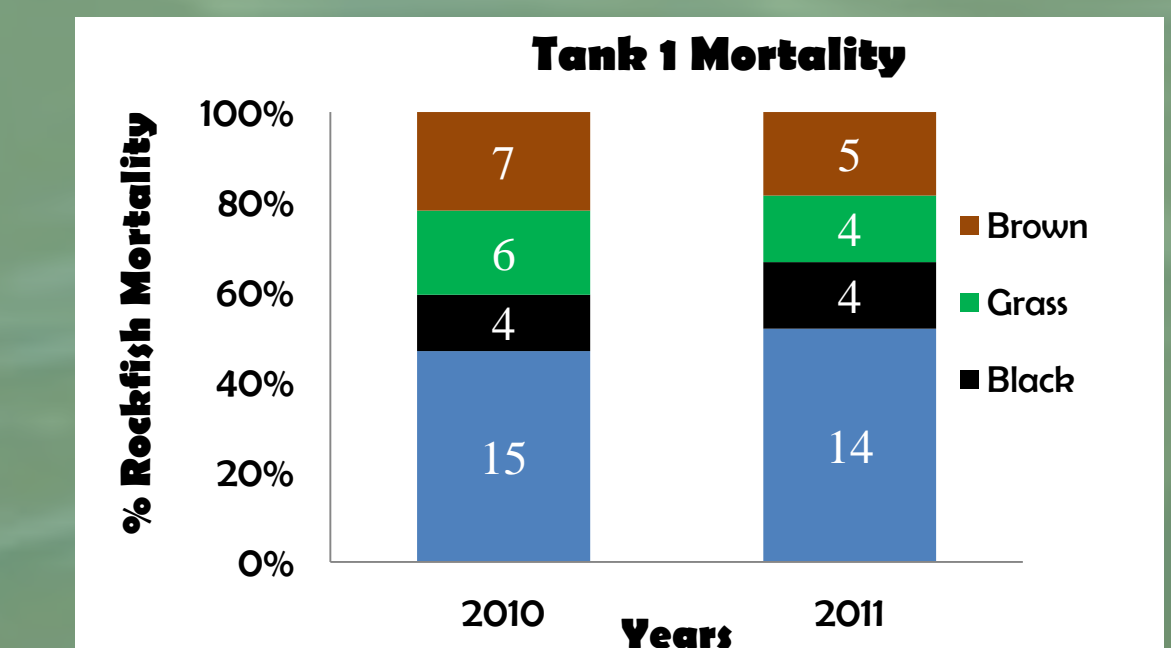


Insulation: Work done by the chiller can be reduced by insulating the cold water in the piping from warmer ambient air temperatures

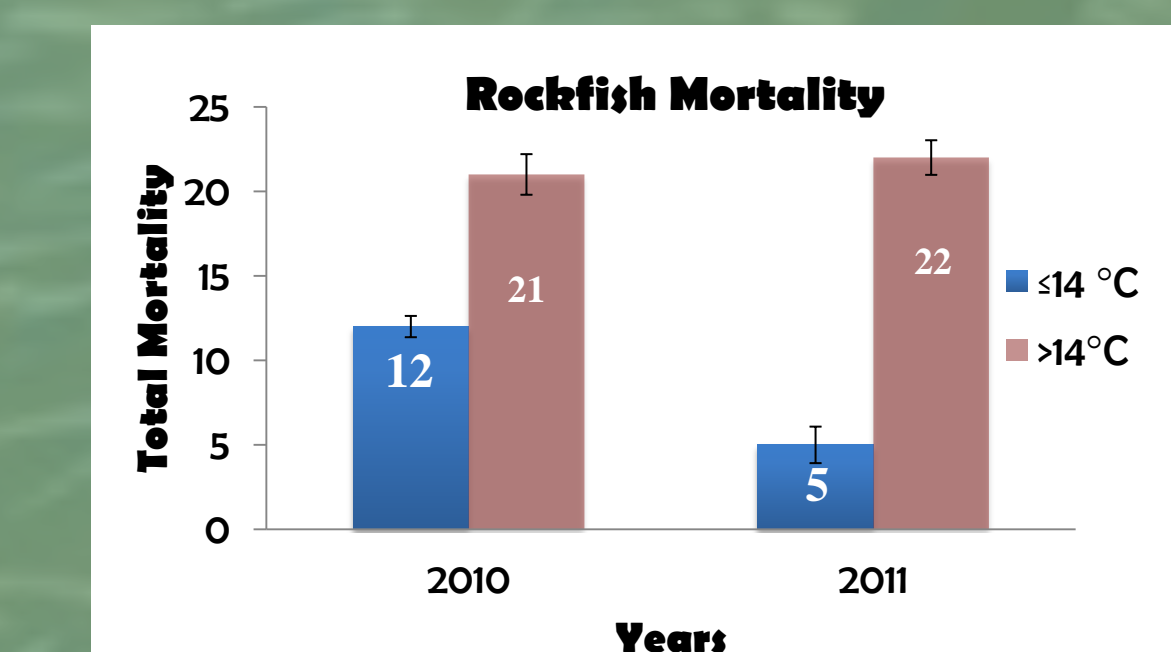
Fan: A fan above the main tanks will encourage heat loss through evaporation

New chiller: A second main chiller will cool the water to meet the needs of the animals

Animal Care



~50% of rockfish mortalities can be avoided by removing black, grass, and brown rockfish



Furthermore, 72% of mortalities occurred when water temperatures were above 14°C

Recommendations

Scenario 1 (Carbon Focused)

Goal: minimize AOTB's greenhouse gas emissions

Includes

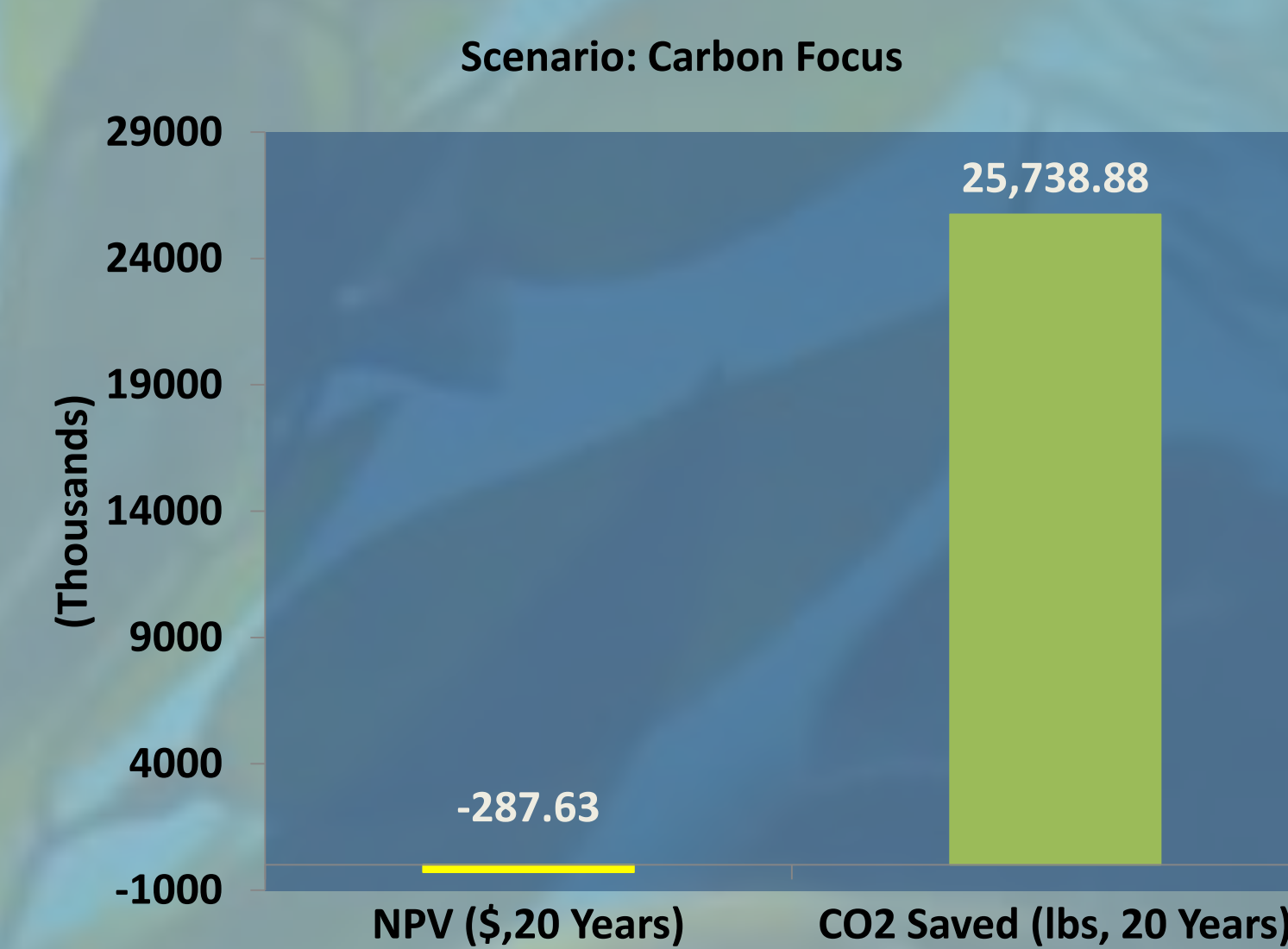
Water Cooling

- Insulation
 - Fan
- ##### Pumping
- Power Conditioners
 - Demand Response Plan
 - Motor Replacement

Other

- CleanPowerSF

CleanPowerSF is an energy provider that offers a renewable alternative to PG&E.



Scenario 2 (Animal Focused)

Goal: improve animal welfare the greenest way possible

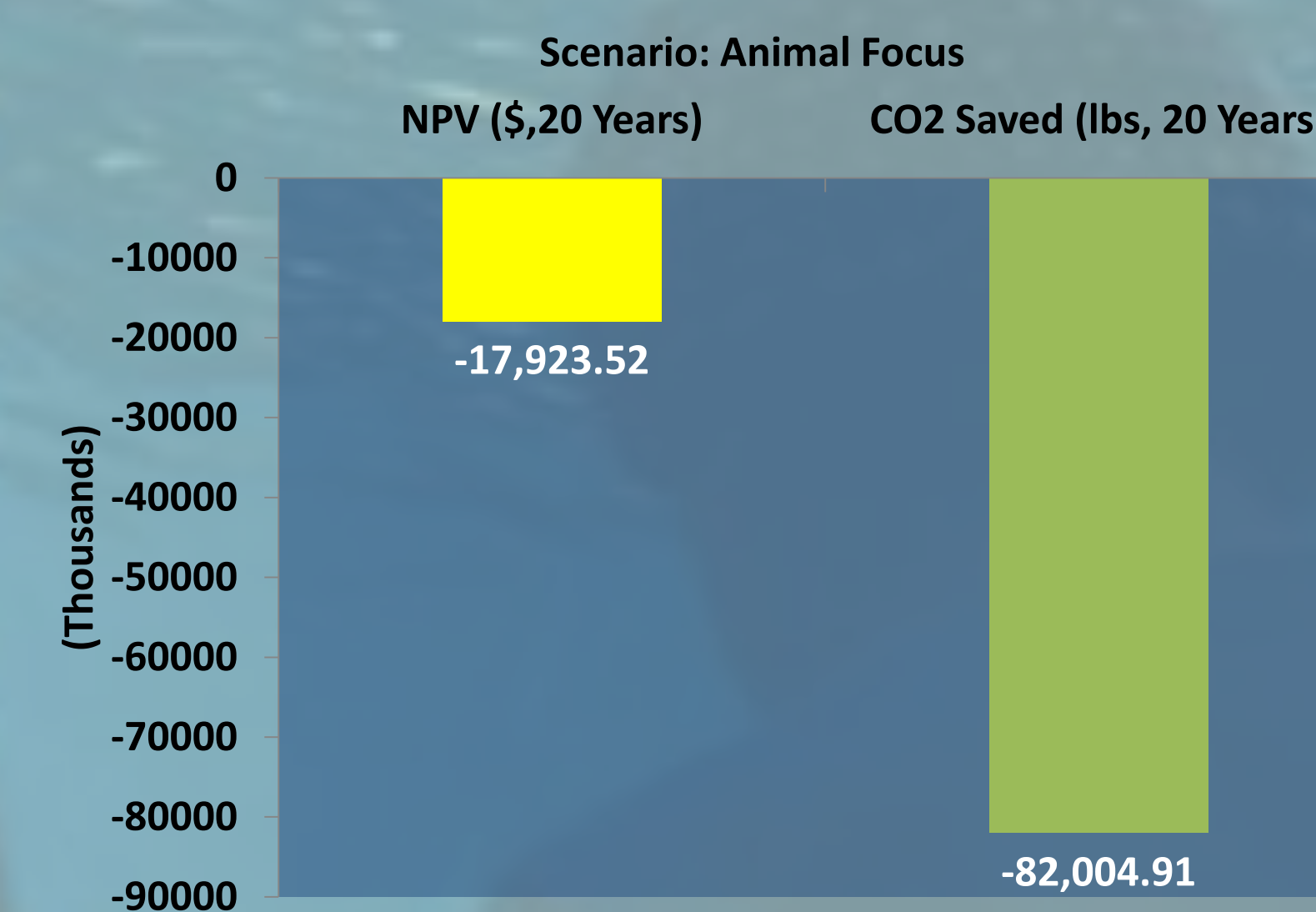
Includes

Water Cooling

- Insulation
- Additional Chiller
- Fan

Pumping

- Power Conditioners
- Demand Response Plan
- Motor Replacement
- Variable Frequency Drive



Scenario 3 (Balanced)

Goal: improve animal welfare and aquarium sustainability in a cost-effective manner

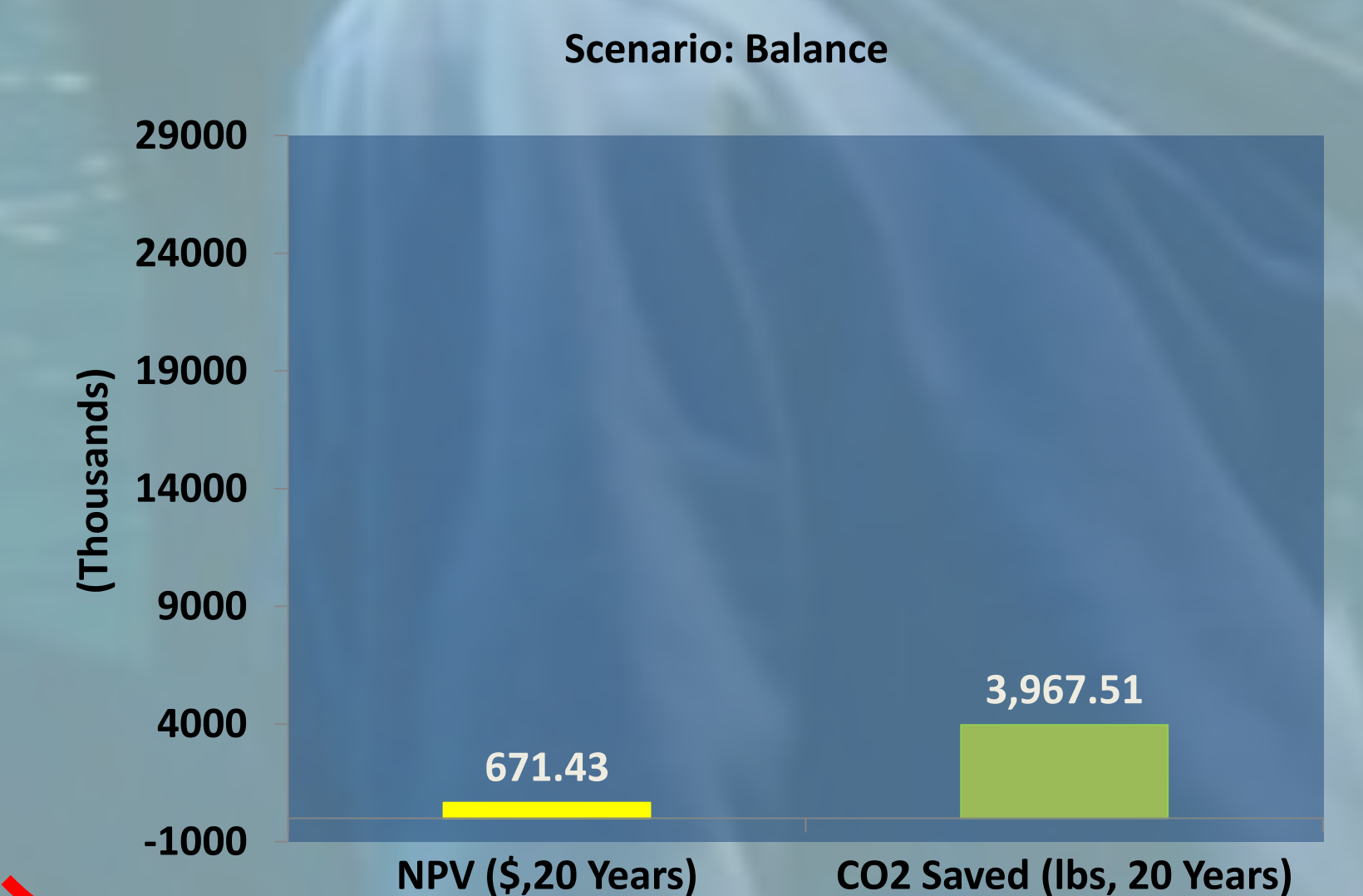
Includes

Water Cooling

- Fan
- Power Conditioners
- Demand Response Plan
- Motor Replacement

Other

- No Sensitive Rockfish



Final Recommendations

To fulfill the requirement set forth by our research question, improving the Aquarium's environmental performance in a cost-effective way while meeting the needs of the marine animals, we recommend Aquarium of the Bay implement the **"Balanced" Scenario.**

Acknowledgements

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