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Anti-Corrosion Technology and Post-Treatment for Marine Ranch Equipment

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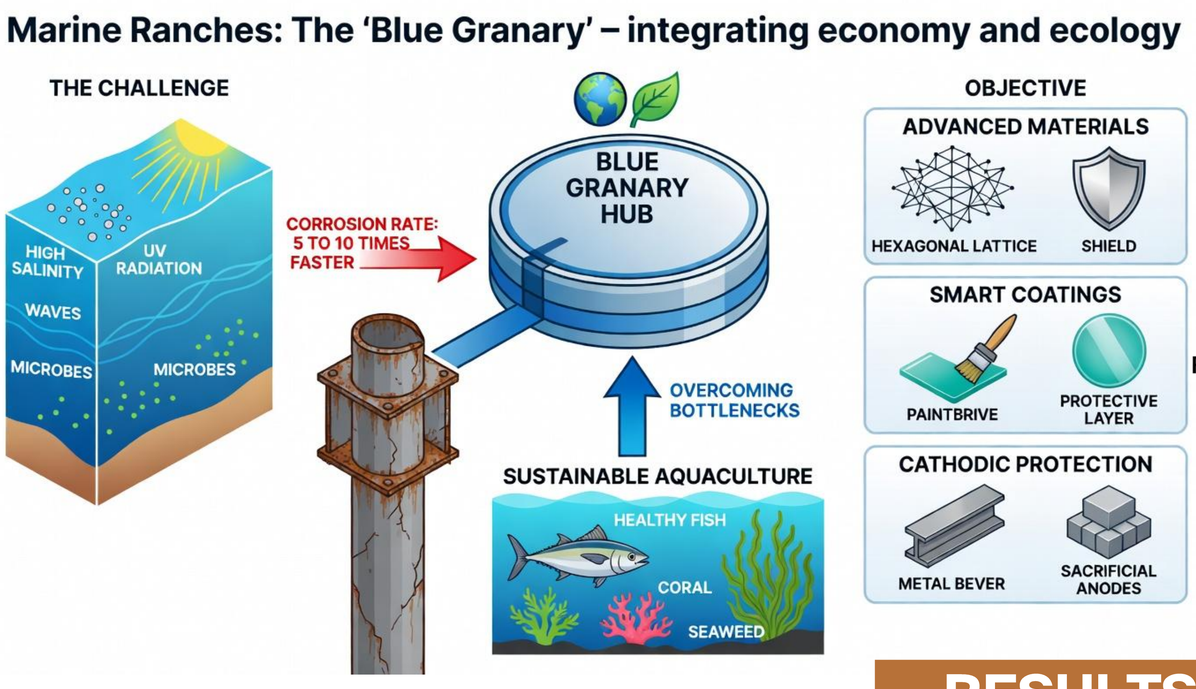
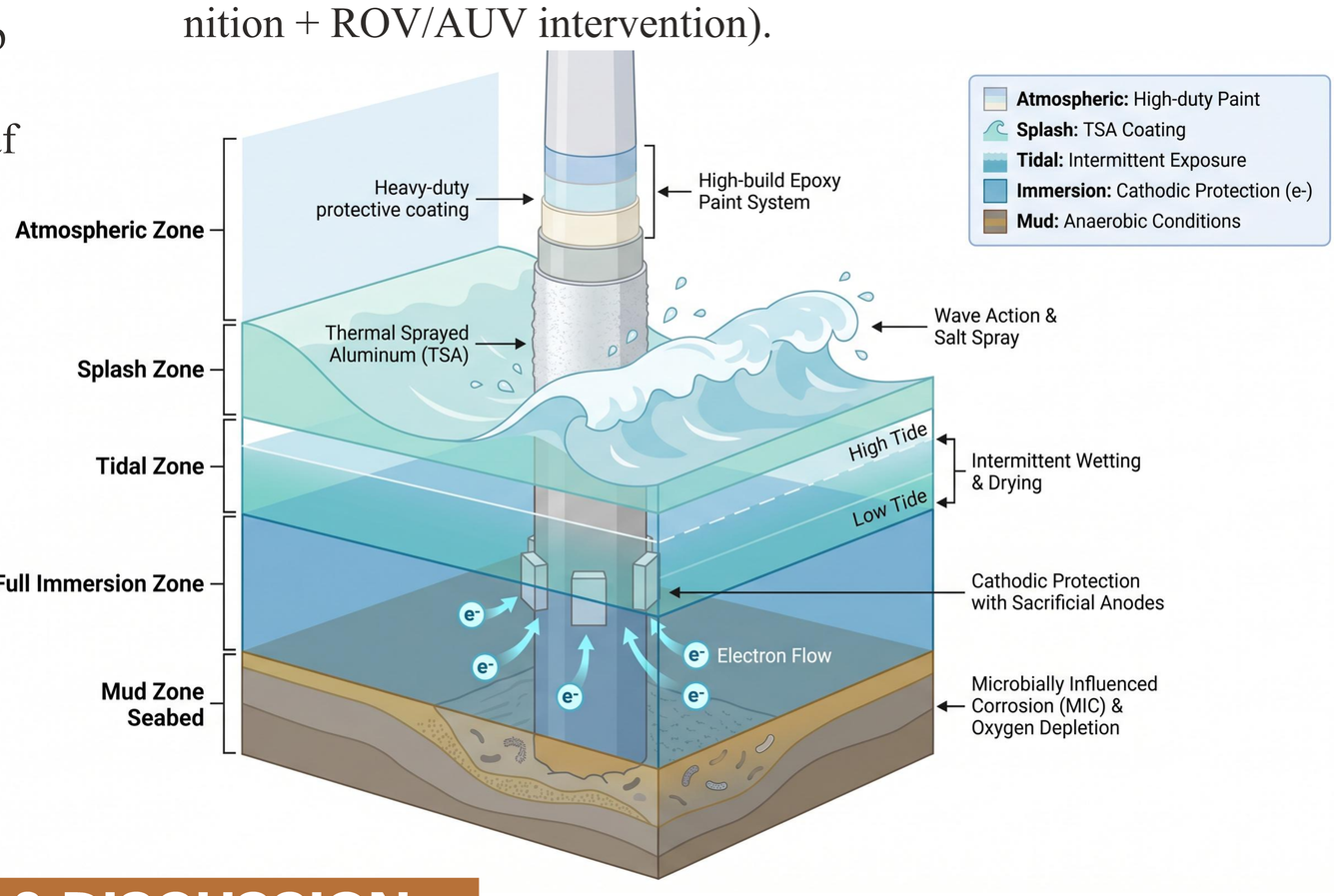
INTRODUCTION & AIM

In recent years, marine ranches have emerged as a strategic platfor m for sustainable aquaculture and ecological restoration.
They play a critical role in achieving global food security and suppo rting carbon neutrality goals.
However, the marine environment presents extreme challenges to en gineering structures.
The corrosion rate of metallic materials in seawater is approximatel y five to ten times higher than in terrestrial environments.
Aim: to summarize a zone-oriented anti-corrosion toolbox and prop ose RAS-based post-treatment as an environmental regulation supp ort to mitigate corrosion-driving factors and improve operational saf ety.



METHOD

- Classify the marine corrosion environment into five zones (at mospheric, splash, tidal, immersion, seabed).
- Match dominant degradation mechanisms (Cl^- attack, oxygen availability, wet–dry cycling, MIC/biofouling) with suitable pr otection technologies.
- Propose RAS as post-treatment to stabilize water chemistry an d reduce internal corrosion risk.
- Outline smart operation options (AI-based fish behavior recog nition + ROV/AUV intervention).



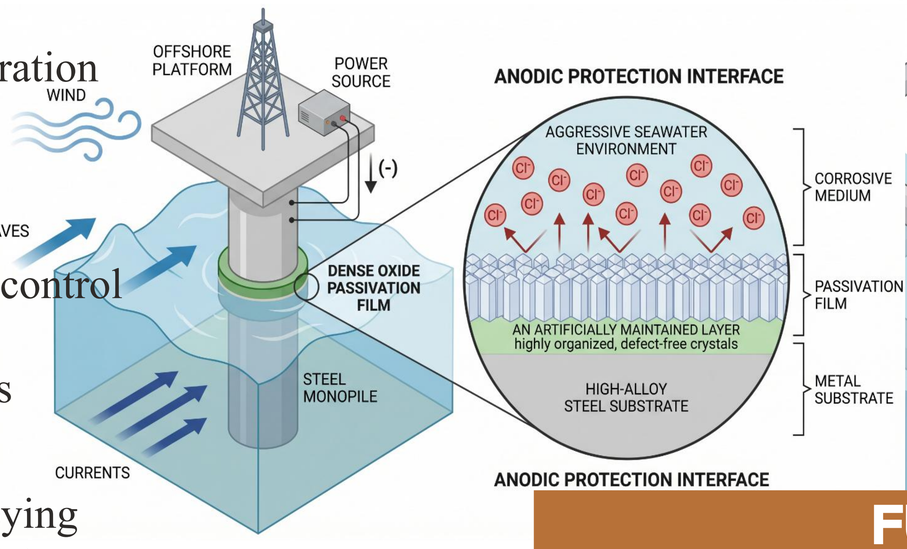
RESULTS & DISCUSSION

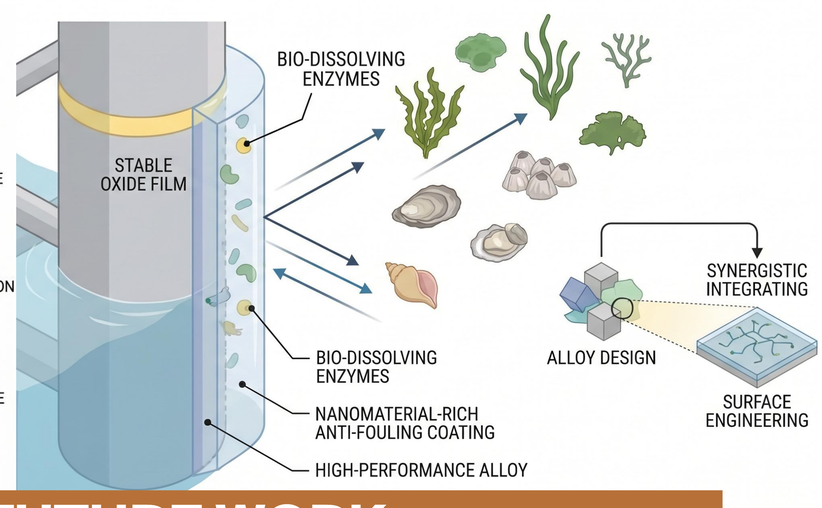
Coating Protection
- Dense barrier layer preventing electrolyte penetration
- Hybrid organic–inorganic coatings
- Zone-specific design for splash & tidal regions

Electrochemical Protection
- Regulates metal potential via cathodic / anodic control
- Sacrificial anode (Al-Zn)
- Active long-term protection in immersion zones

Alloy Material Selection
- Intrinsic corrosion resistance via Cr/Ni/Mo alloying
- Stable passive oxide film formation (Al_2O_3, TiO_2)
- Surface engineering: MAO, anodic oxidation

Biological Anti-Corrosion
- Biofilms cause MIC and accelerate local corrosion
- Nanomaterial-rich anti-fouling coatings inhibit biofilm formation
- Integration of antifouling coatings and intelligent cleaning technologies



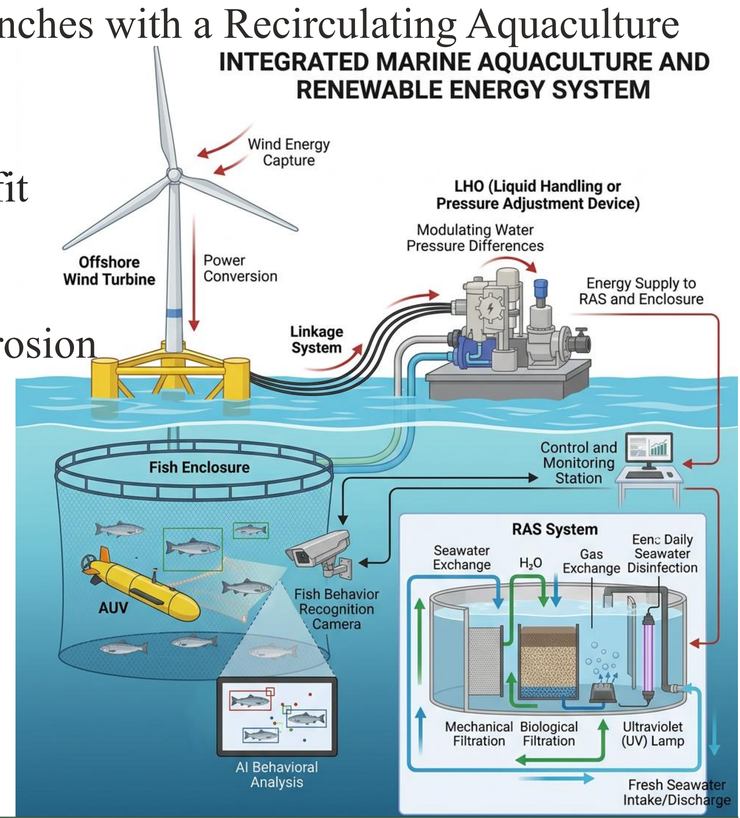


FUTURE WORK

We propose linking marine ranches with a Recirculating Aquaculture System (RAS).

Post-treatment: RAS System
Indirect Anti-Corrosion Benefit
- Stabilize Cl^- & O_2 levels
- Reduce pitting / MIC risk
- Slow internal equipment corrosion

RAS is not a primary anti-co rrosion technology, but an en vironmental regulation syste m that reduces corrosion-dri ving factors and complement s conventional coating & cat hodic protection strategies.



CONCLUSIONS

- A multi-layer anti-corrosion system is essential, combining coatings, electrochemical protection, alloy optimization, and biological control.
- Post-treatment technologies, particularly the RAS system, are critical for mitigating environmental and biological impacts of corrosion.
- The integration of artificial intelligence and underwater robotics offers a new paradigm for intelligent marine ranching.