Ocean Activation and Weather Risk Reduction through Artificial Upwelling

Cooling of Sea Surface Temperature
Wave-driven Upwelling Device

Climate Foundation Online Conference
"Why Wave-Powered, Low-Tech Cooling Fits Cebu"

Reasons for Sea Surface Temperature (SST) Rise and Countermeasures

Near-infrared and infrared solar energy is almost completely absorbed at "several millimeters to several centimeters below the sea surface"

Reasons for SST (Sea Surface Temperature) Rise

1. Visible light penetrates deeply, but infrared does not → Surface heating tends to dominate

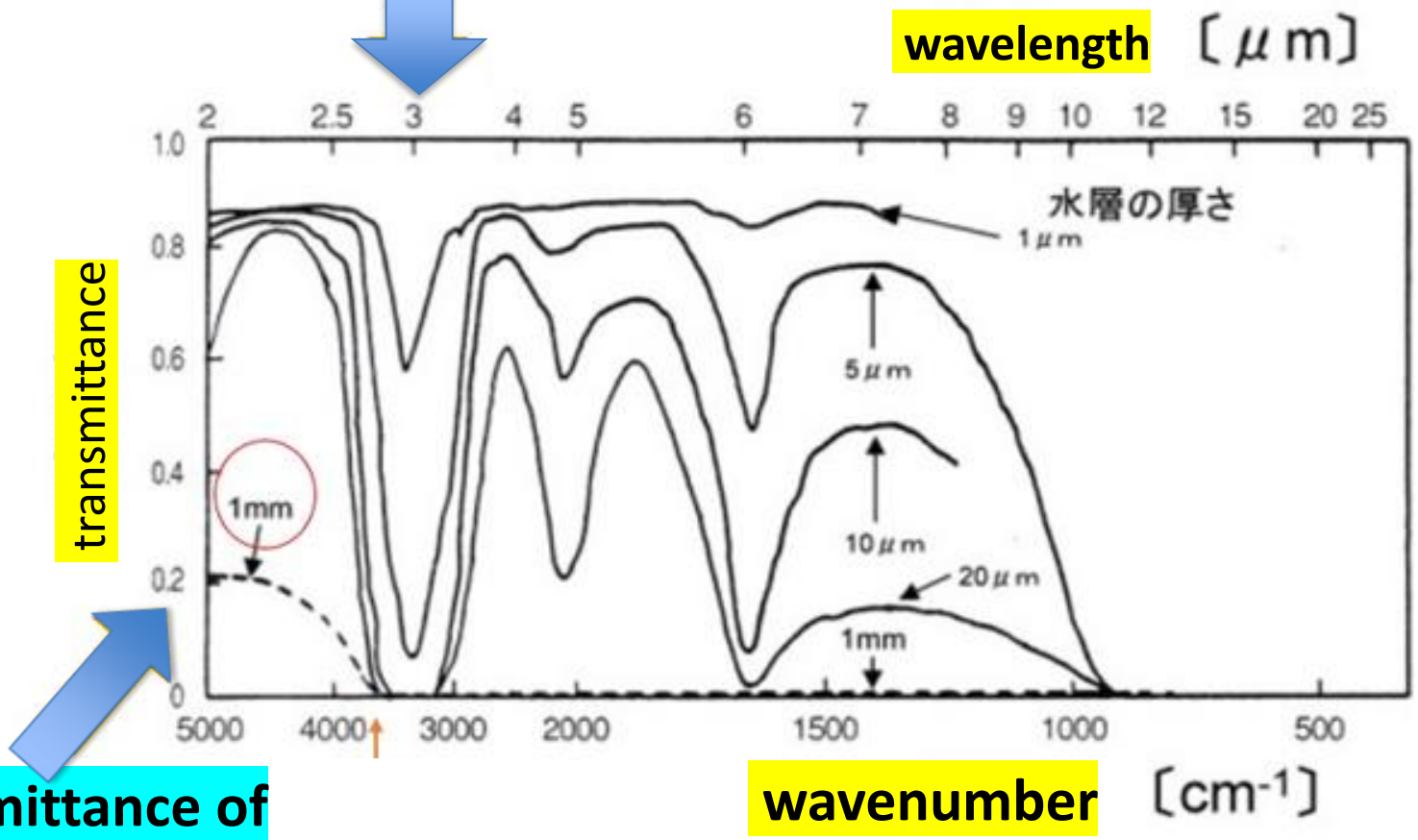
2. Peak solar energy occurs around 0.5–1 μm → Most concentrated in the surface layer (mm–cm)

3. Under weak wind conditions, mixing does not occur, forming a heat layer

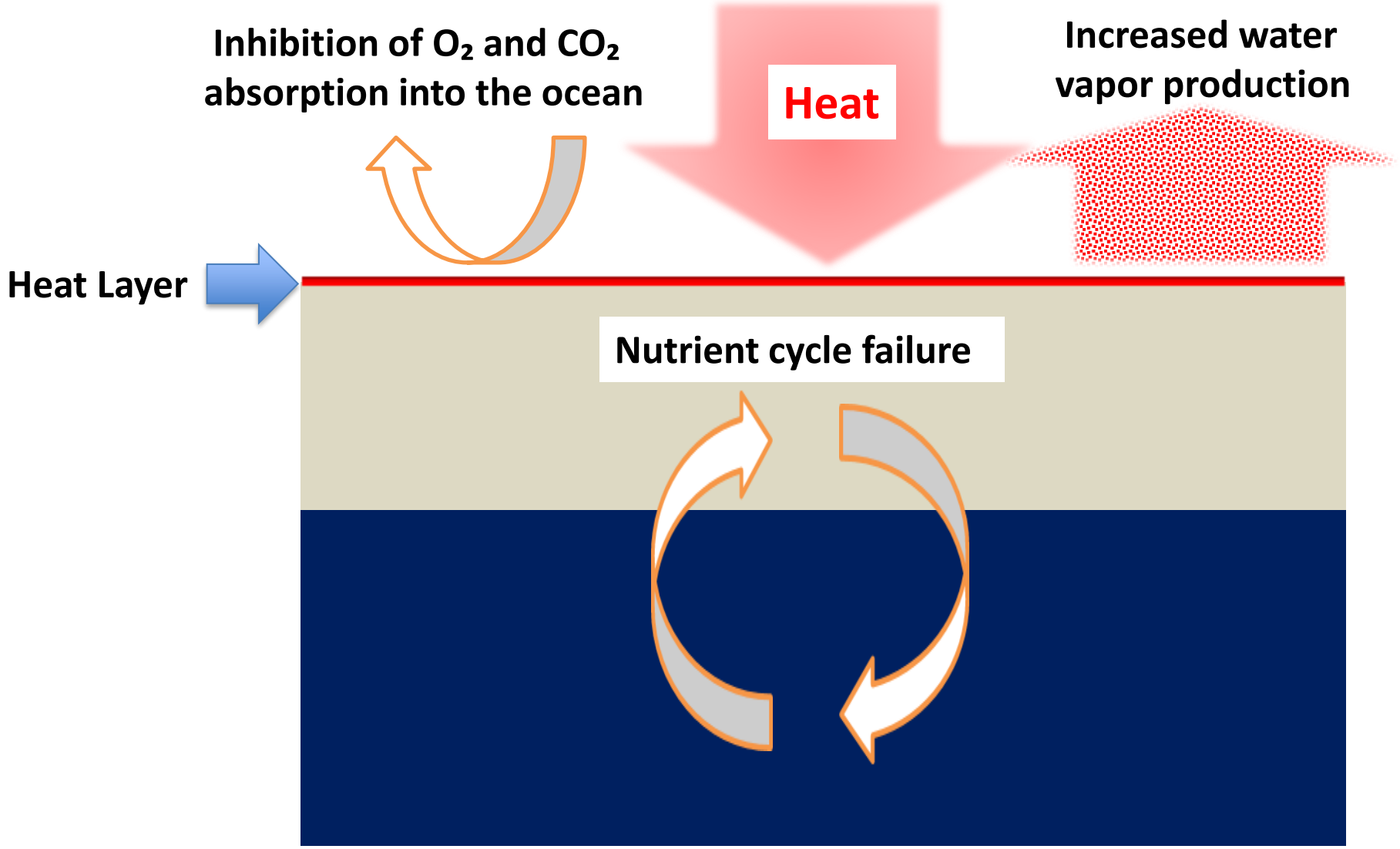
Breaking this layer through artificial upwelling can suppress the SST peak

Water's Infrared Absorption Specificity

A 1 mm layer of water absorbs all wavelengths of 3 μm or longer



Three Risks from Heat Layers

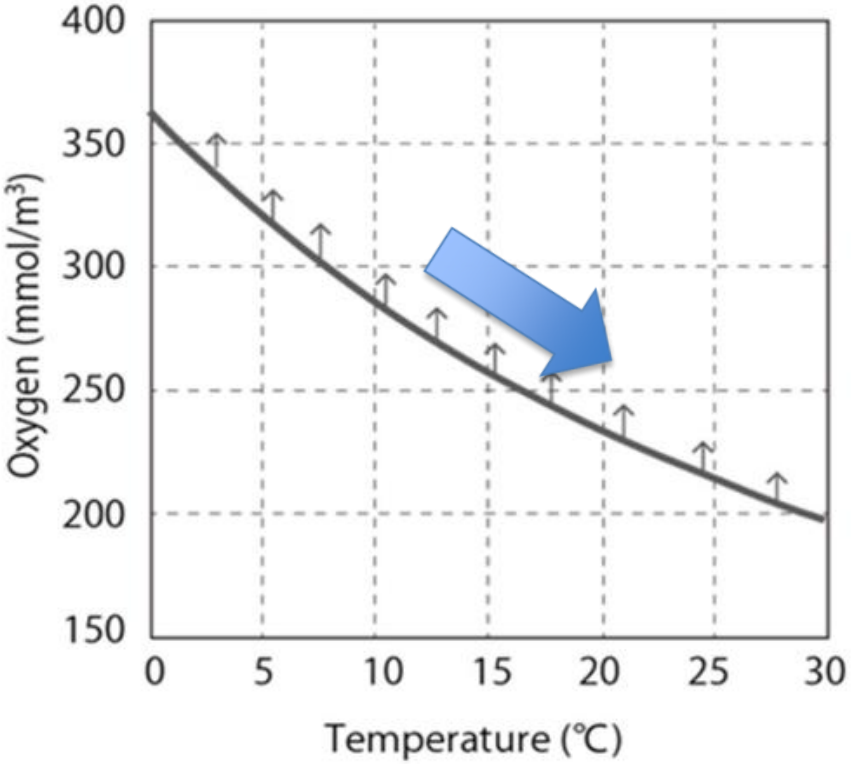


Weather Risks Posed by Increased Water Vapor

① Rising Sea Surface Temperature (SST)
↓
② Increased Evaporation (Ocean → Atmosphere)
↓
③ Increased atmospheric water vapor content
↓
④ Increased latent heat release and enhanced greenhouse effect
↓
⑤ Heavy downpours, intensified typhoons, prolonged heatwaves
↓
⑥ Increased Flooding, Landslides, and Socioeconomic Risks

Rising water temperature and decreased dissolved O_2 and CO_2 levels

O_2



CO_2

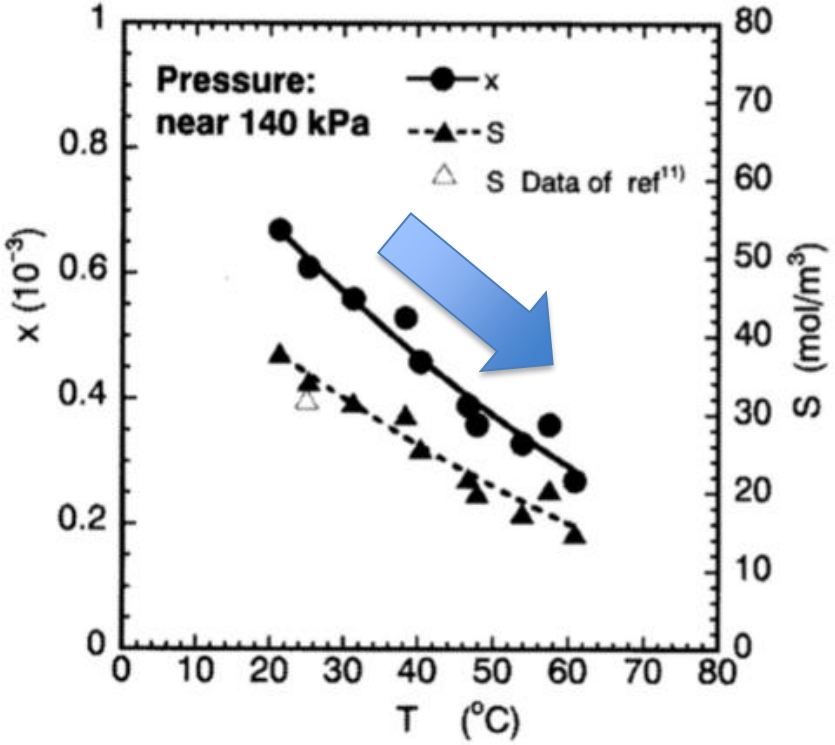


Fig.4 Solubilities of CO_2 in seawater at various temperatures.

Risks from reduced dissolved O_2 and CO_2 levels

Item	Physical and Chemical Changes	Ecological and Environmental Risks	Social and Economic Risks
Decreased dissolved CO_2	Release from seawater to atmosphere	Weakening of blue carbon functions	Diminished Ocean Function as a Climate Change Mitigation Strategy
Decreased Dissolved Oxygen (DO)	Decreased oxygen solubility due to rising water temperatures	Hypoxia and Oxygen Depletion Stress on fish and benthic organisms	Decreased Catch Impact on the fishing industry
Compound effects	High temperature + low oxygen + low CO_2 absorption	Mass mortality Decreased Ecosystem Resilience	Regional Economic and Food Security Risks

Risks Associated with Vertical Agitation Cessation

Impact Items	Physical Changes	Ecological Risk	Social and Management Risks
Nutrient Supply Cessation	Nutrient Transport Blocked	Decline in phytoplankton	Decline in fishery productivity
Cessation of dissolved oxygen supply	Oxygen fails to reach deeper layers	Reduction in benthic organism habitats	Permanent establishment of hypoxic water masses
Uneven distribution of organic matter decomposition	Decomposition progresses in deep layers	Hydrogen sulfide generation Risk of Mass Mortality	Damage expansion during red tide/blue tide occurrences
Disruption of the food web	Primary production and Spatial mismatch between Spatial Discrepancy	Simplification of Ecosystems	Decline in fishery resources

Integrated Countermeasures Against Various Risks

Mechanism of Wave-Type Upwelling Pumps

- Transporting deep water to the surface using only wave energy
- Reduces surface SST (heat layer) through cold water supply
- Restores vertical mixing and mitigates stratification

Primary Mitigated Risks

- Evaporation suppression → Reduces extreme weather risks caused by water vapor
- Restoration of CO_2 absorption capacity and dissolved oxygen
- Restoration of primary production and enhanced ecosystem resilience

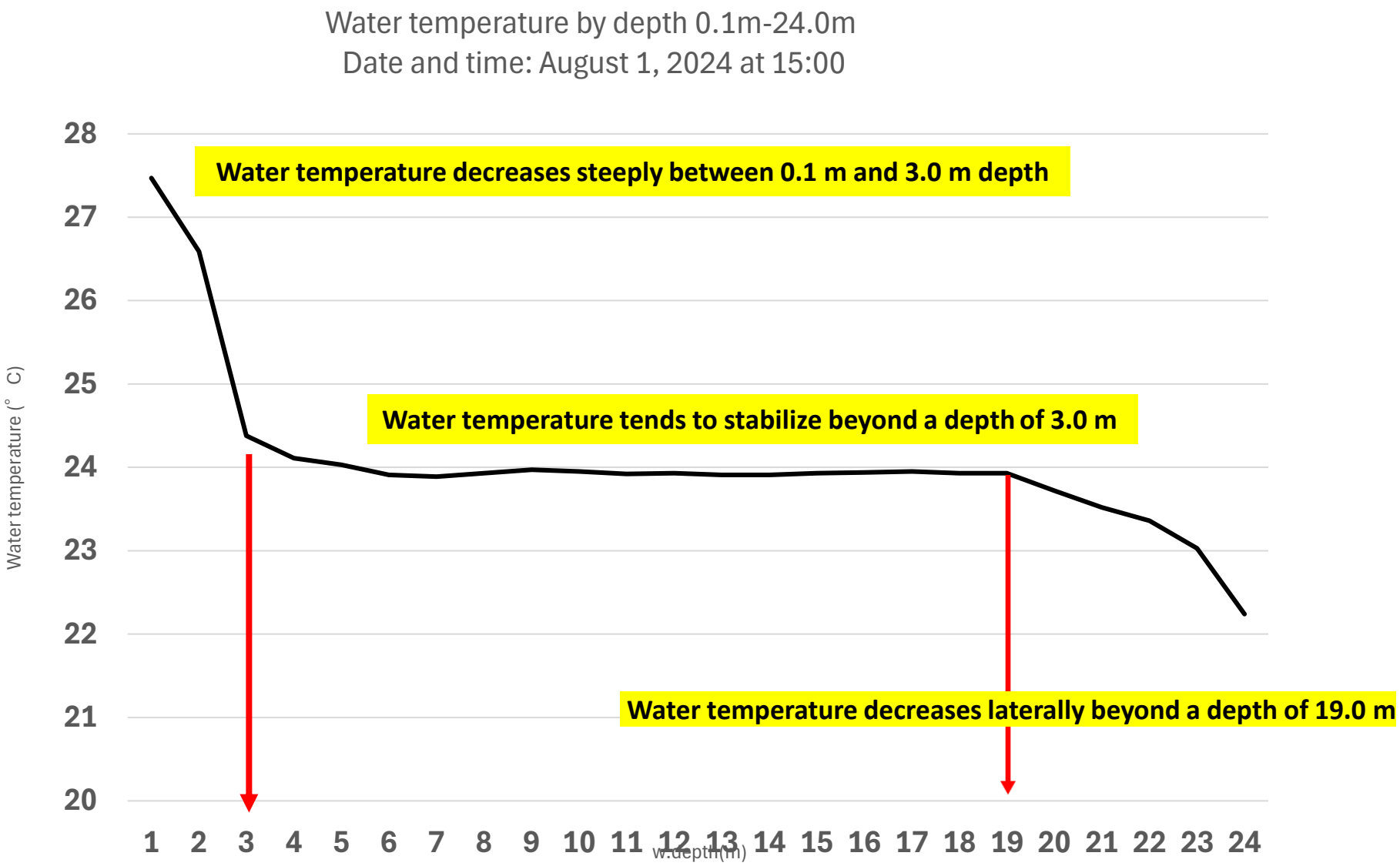
Technical and social advantages

- No external power required ・ Low cost・Long-term durability・DIY capability
- Deployable in coastal areas, coral reef zones, and shellfish/seaweed aquaculture sites

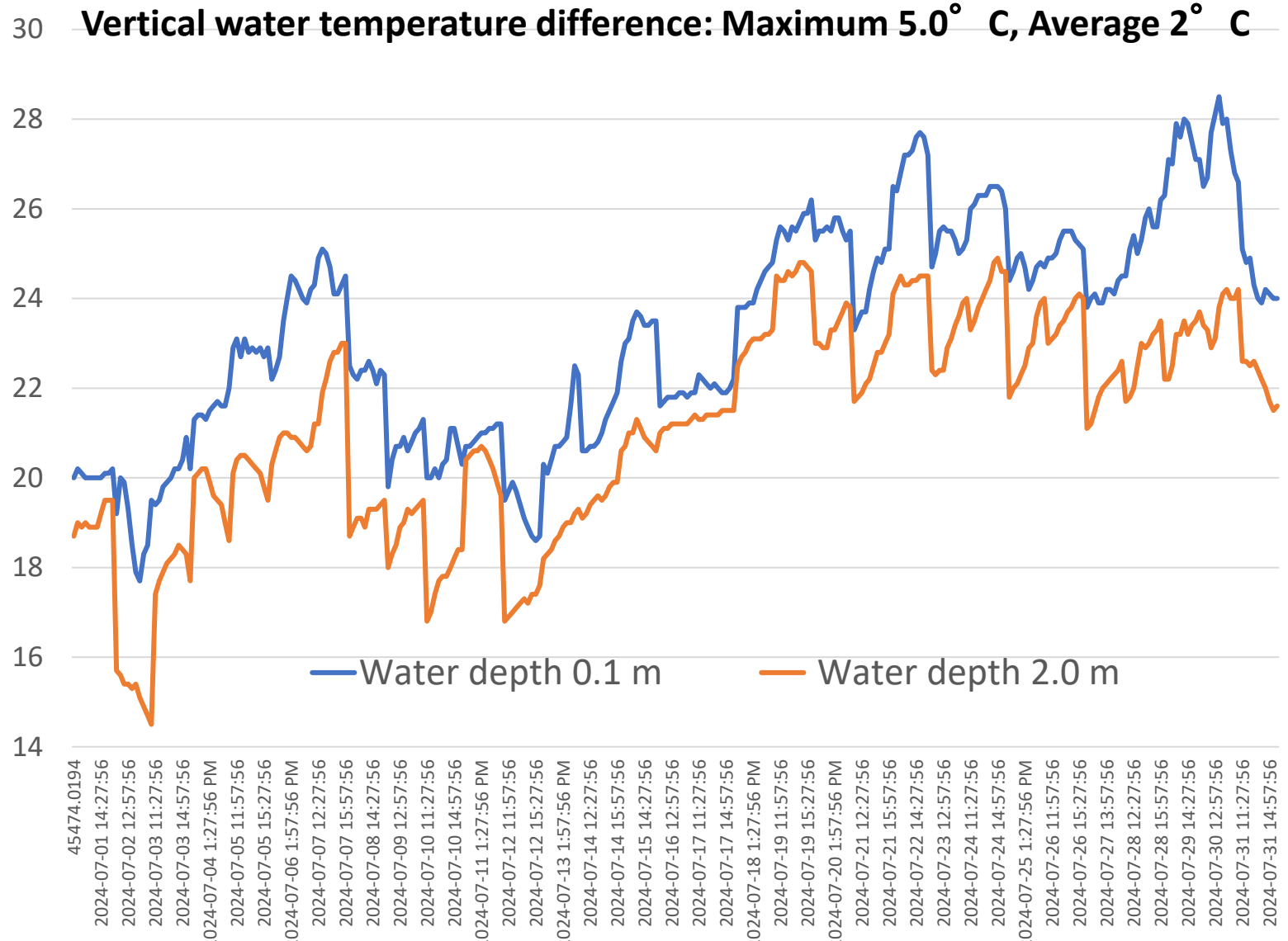
Simple Comparison of SST Cooling Technologies

Method	Cooling Intensity	Energy	Scale	Implementability
Artificial Upwelling	◎	Wave/Power	Medium to Large	△
Vertical Mixing	○	Wave/Tide	Medium	○
Albedo control	△	Small	Large (theoretical)	△
Shade	○ (Local)	Small	Small	◎
Ecosystem	△	Nature	Medium	○

Vertical Water Temperature in the Central Ise Bay: 15:00, August 1, 2024

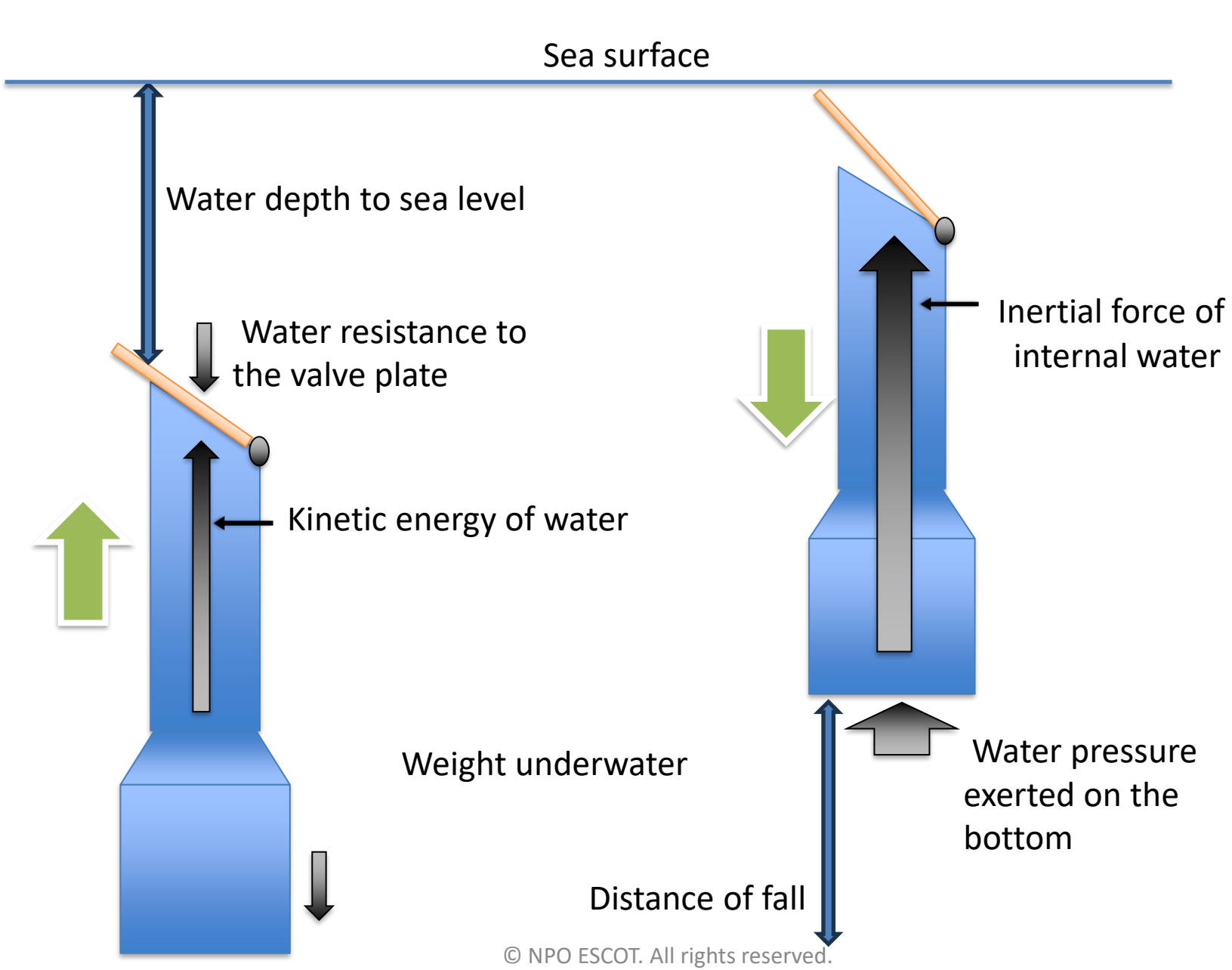


Vertical water temperature difference at Onjuku Iwahata Fishing Port, Chiba Prefecture = Water depth 0.1 m: 2.0 m July 1, 2024 - July 31, 2024

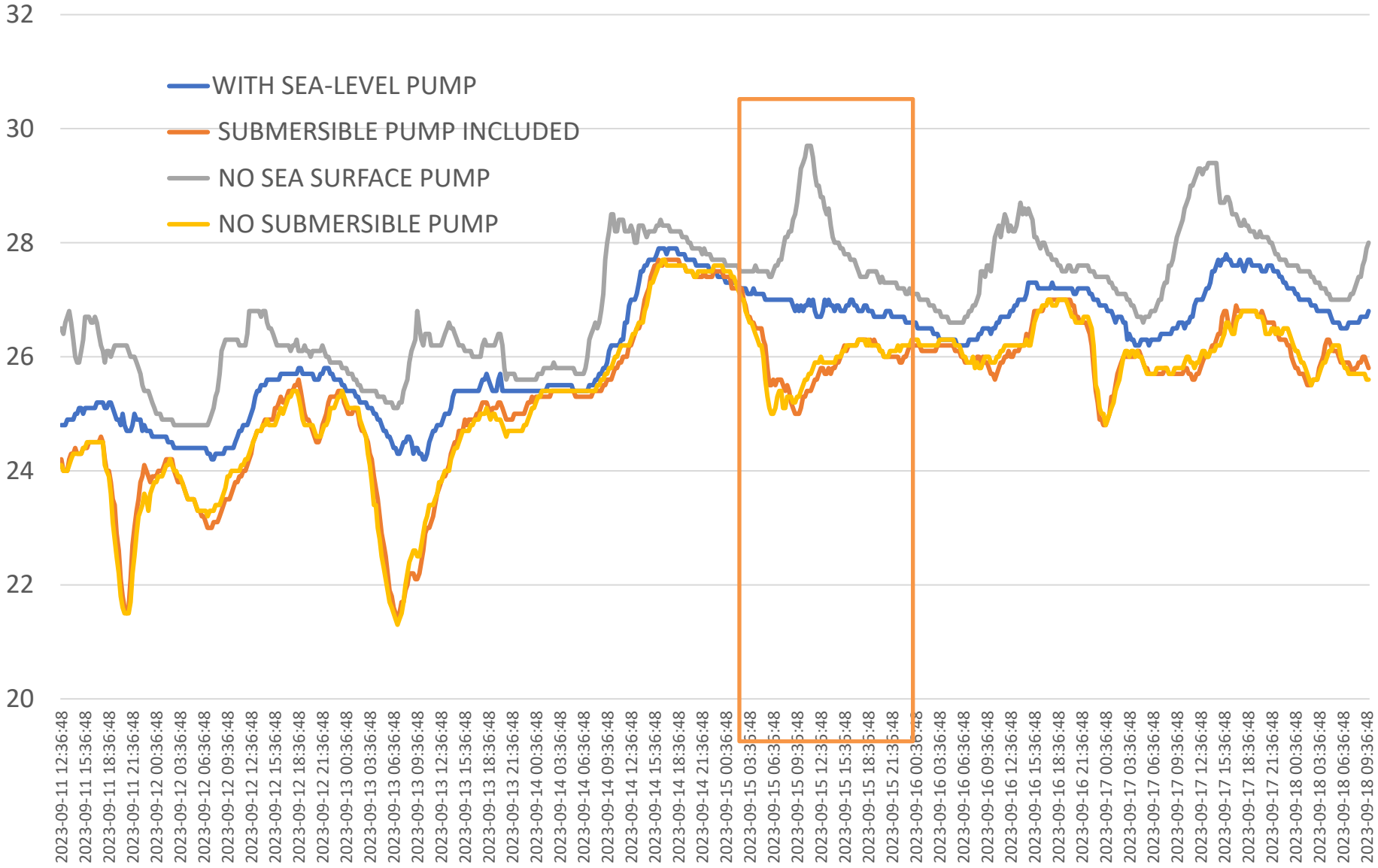


Wave-type Upwelling Pump

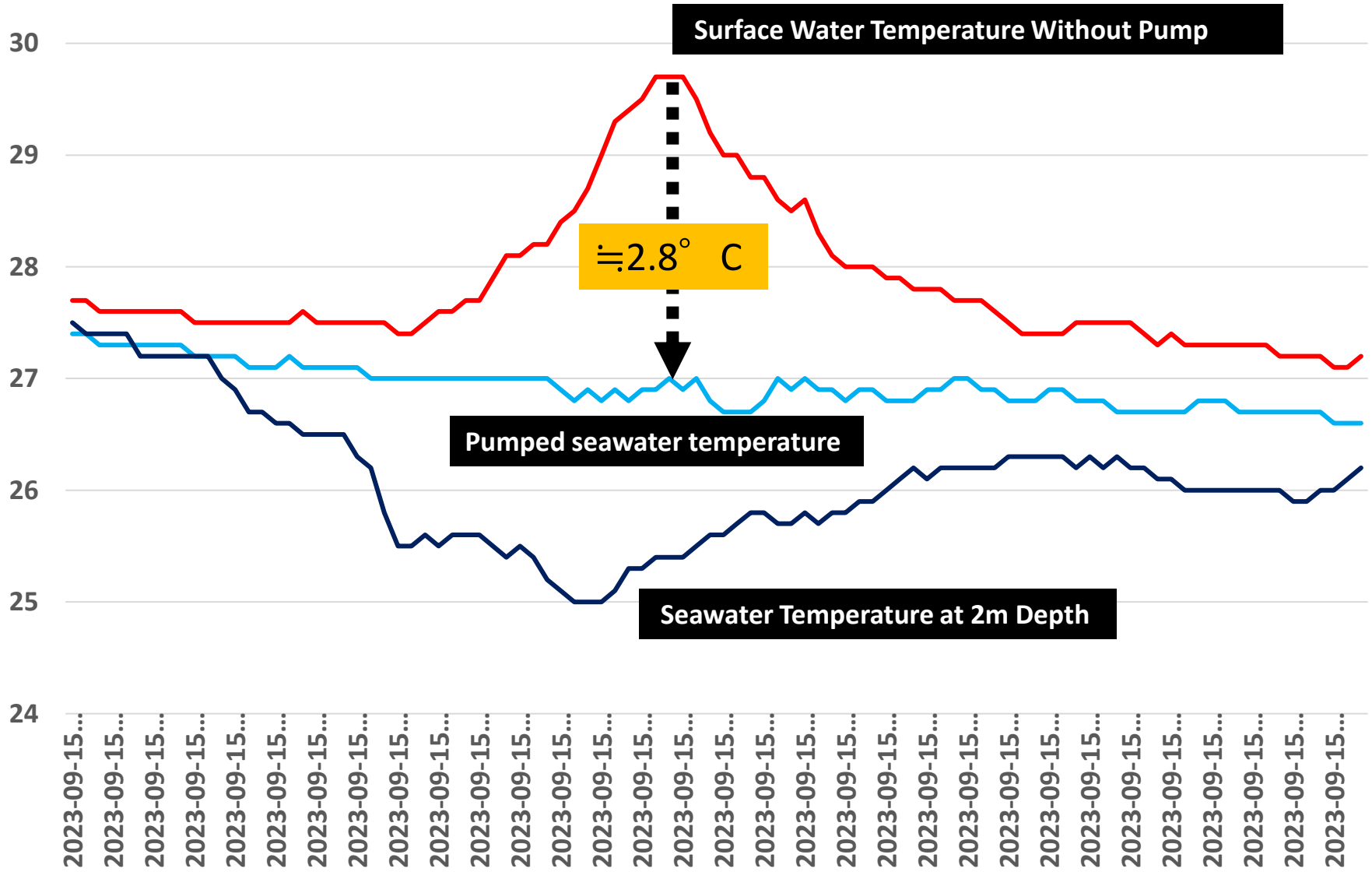
Wave-type upwelling pump



Sea Surface Cooling Effect = Comparison of Sea Surface Temperature with and without Pumping September 11-18, 2023



Sea Surface Temperature Cooling Effect: 2023.9.15



Prediction of Diffusion Effects in Seawater Pumping Using Upwelling Pumps