

# Potential OTEC Impacts in the Hawaiian Marine Environment

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# Operational Impacts

- Discharge
  - Biostimulation/Inhibition
  - Effects on Fishery Life History
  - Effects on Coral Reefs
  - Physical Impacts
  - Chemical Impacts
  - Regional Impacts
- Impacts to Endangered Species
- Acoustic and Electromagnetic Effects



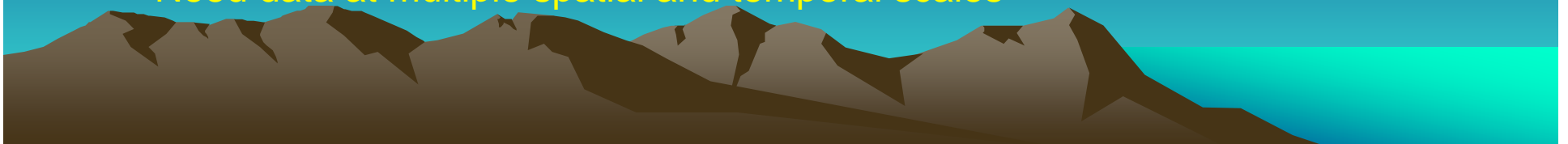
# Discharge - Biostimulation/Inhibition

- Elevated levels of dissolved inorganic nutrients, primarily phosphate, nitrate and silicate expected to promote blooms of photosynthetic organisms if discharged and contained within the upper ocean or in coastal waters.
  - Changes to microbiology of area/organisms under plume influence
  - Changes to phytoplankton stock composition/concentration and activity rates
  - Changes to zooplankton stock composition/concentration and activity i.e. diel migration
  - Changes to ichthyoplankton stock composition/concentration and activity rates
  - Promotion of harmful algal blooms
  - Promotion of ciguatoxin-producing algae
  - Eggs and larvae movement and layering
- Impacts of elevated levels of dissolved carbon dioxide if discharge contacts the atmosphere.



# Discharge - Impact on Fisheries Life History

- Greater primary production and/or truncated trophic relationships
- Changes to recruitment, mortality, larval ecology
- Changes to temporal and spatial distribution of the early life stages
- Loss of resiliency in complex food webs
- Increase/decrease in fish production
- Changes to taxonomic composition, standing crop, stock structure, age distribution, fecundity, and production
- Dinoflagellate blooms either harm fish populations or make fish inedible
- Need data at multiple spatial and temporal scales



# Discharge - Impacts on Fisheries

- Commercial
  - No longline activity in proposed region, but may impact seasonal opelu and ahi fisheries
  - Impact largely on recruitment
- Recreational
  - Close to numerous small boat harbors
  - May serve as very large FADS
  - May increase/reduce effort/harvest
  - May increase productivity
  - May increase entrainment and or morbidity of eggs, larvae, or juveniles
  - May cause increase in bioaccumulation of toxins
- Changes to Maximum Sustainable Yield (MSY), due to inability to compensate for entrainment or impingement losses, and potential increase in effort



# Coral Reefs

- While few deep-water coral resources have been catalogued at the proposed site, inshore coral reefs in the area are extensive and in relatively good condition.
- Provide habitat for numerous fishery resources, at least during some portion of the individual species' life cycle.
- Impacts on reef fishery habitats may be of greater importance than direct impact on the species themselves (eggs, larvae, adults).
- Physical destruction of coral reefs can sometimes lead to an increase in invasive species and the incidence of ciguatera poisoning.



# Physical Impacts - Discharge

- Vertical motion and dilution of the effluent plume dependent upon the density of the discharge, the configuration of the discharge outlet, the vertical receiving water density gradients, and the presence of currents
- Movement of water mass into the photic zone or upwelled close to shore as a result of Eckman transport
- Impacts of plume settlement on benthos
- Impacts of long or short trajectories for dilution
- Changes to local stratification in terms of salinity and temperature, trace metal concentrations, lower pH of the local ecosystem, and subsequent biological impacts



# Regional Effects

- Effects of large mixed discharge plume in a density stratified environment
- Possible changes to ambient circulation, thermocline/halocline, and concentration/distribution of effluent and water column constituents
- Chemical and biogeochemical impacts of closely spaced commercial OTEC systems can interfere and alter the ocean temperature profile with possible negative environmental consequences
- Impacts from OTEC plumes and operations on nearby uses (aquaculture and recreational uses)





# Endangered Species

- Marine mammals
  - Hawaiian monk seal *Monachus schauinslandi*
  - Humpback whale *Megaptera novaeangliae*
  - False Killer Whale *Pseudorca crassidens*
  - Sperm Whale *Physeter macrocephalus*
  - Sei whale *Balaenoptera borealis* E
  - Cuvier's Beaked Whale *Ziphius cavirostris*
  - Fin whale *Balaenoptera physalus*
  - Spenn whale *Physeter calOdoll*
- Sea Turtles
  - Loggerhead sea turtle *Caretta caretta*
  - Green sea turtle *Chelonia mydas*
  - Leatherback sea turtle *Dermochelys coriacea*
  - Hawksbill sea rurtle *Eretmochelys imbricata*
  - Olive Ridley sea turtle *Lepidochelys olivacea*
- Birds
  - Newel's shearwater *Puffinus auricularis newelli*
  - Hawaiian dark-romped petrel *Pterodroma phaeopygia sandwichensis*



# Existing Data from Recent Work

- Hawaiian Ocean Observing System (HIOOS & PACIOOS)
- HURL, HMRG, PIBHMG mapping and benthic characterization work
- Long-term monitoring programs at UH, including HOTS, HF Radio oceanography, internal tides, etc
- USGS studies of geology and dredge spoils
- Microbiology, plankton, plume, circulation, hydrodynamic modeling, benthos characterization as part of Mamala Bay sewage effluent work
- EISs from Hukilau Farms, Barbers Point Harbor, Kahe Power Plant, Ko Olina, etc.
- NOAA and State of Hawaii coral mapping work and characterization of damage from *Casitas* and *Port Royal* groundings

Question: Is the information from this work at the appropriate temporal and spatial resolution? How much is in usable form?



# Intake - Impingement

- Occurs when organisms too large to pass through the intake screen, are pulled against it, and are unable to escape due to the intake current velocity. Causes ecological (loss of a large number of organisms), operational (reduction in cooling water flow), and cost problem (removal and disposal of organisms). Schooling fishes are especially susceptible, and impingement mortalities may involve millions of individuals. Unknown impacts on endangered species such as monk seals and young sea turtles.
- Impingement rates will depend on intake location and velocity, time of day/season, behavior characteristics of the populations of organisms associated with the plant site the year.
- Plant may serve as a fish-attracting device and concentrate organisms where they are in danger of being impinged or entrained.
- Impinged organisms generally fall into the micronekton size category (2-20 cm) and include fishes, macroplanktonic crustaceans, cephalopods, and gelatinous organisms such as coelenterates, salps, and ctenophores. Micronekton are an important intermediate step in the food chain between the zooplankton and commercially important fishes.

# Intake - Primary Entrainment

- Any organism small enough to pass through the intake screens will be entrained in the seawater flowing through the heat exchangers (primary entrainment).
- Organisms subjected to thermal and mechanical stresses as a result of changes in pressure and temperature, shear and acceleration forces, abrasion, and collision with structures.
- Organisms subjected to biocides used to clean the surfaces of the heat exchangers, anticorrosion agents, and corrosion products.



# Intake - Secondary Entrainment

- Secondary entrainment refers to the capture of organisms in discharge waters (effluent plume) as a result of turbulent mixing or behavioral responses.
- The rate at which organisms are entrained in this manner will depend on the discharge flow rate, the near-field dilution, and the average population density along the near-field trajectory of the plume.



# Acoustical and Electromagnetic Field (EMF)

- Noise from plant operation will be principally from the water pumps and the generators. Additional noise would be generated by the actual movement of the water through the system and out the discharge.
- Possible impact on marine mammal echolocation and communication, and on certain coral reef organisms.
- Interference with marine organisms sensitive to electric fields.



# Trace Metals and Biocides

- Variety of toxic metals leached in small amounts through heat exchangers
- Biocides include chlorine and other toxic agents
- Ammonia most common working fluid
- Need to determine risks of bioaccumulation and toxicity during normal operations and in event of spill

