Ocean Thermal Energy Conversion: Potential Environmental Impacts and Fisheries

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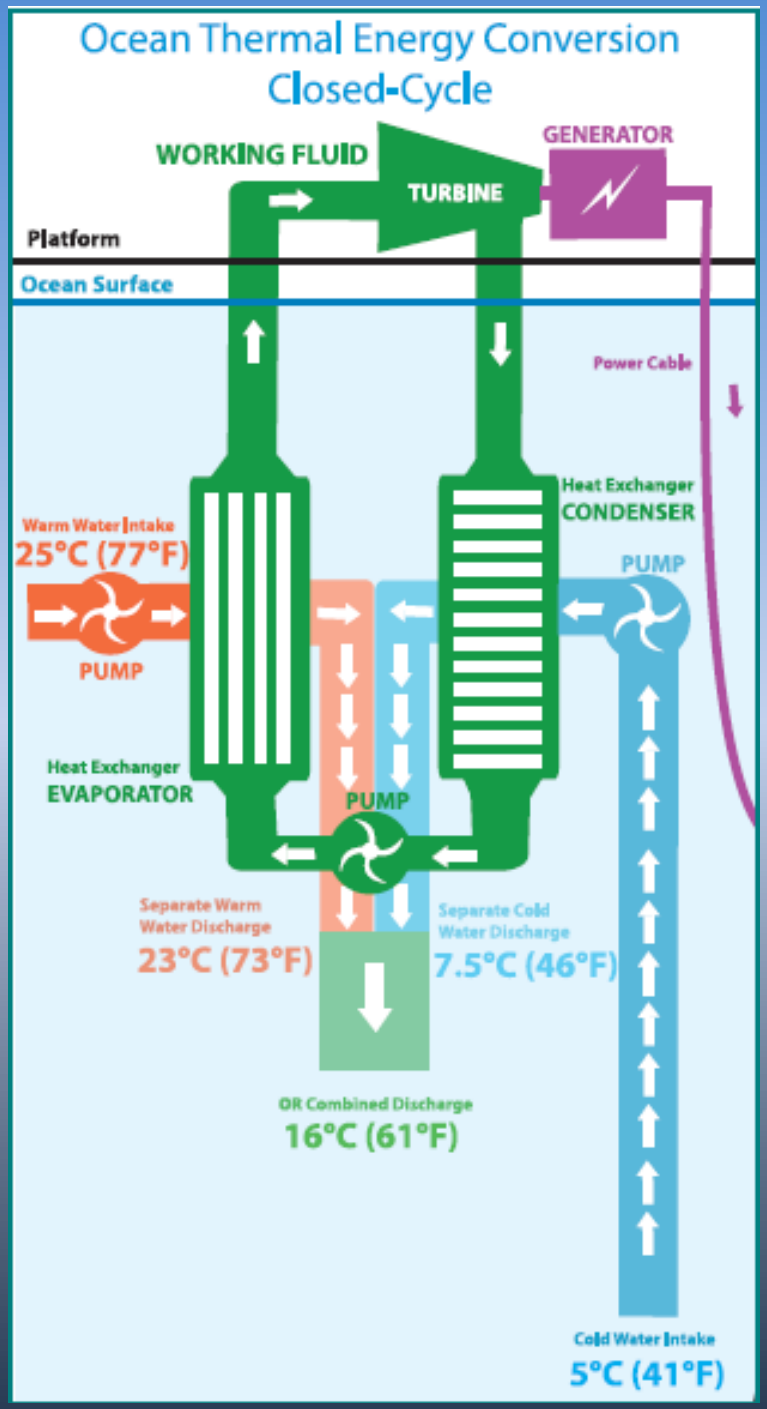
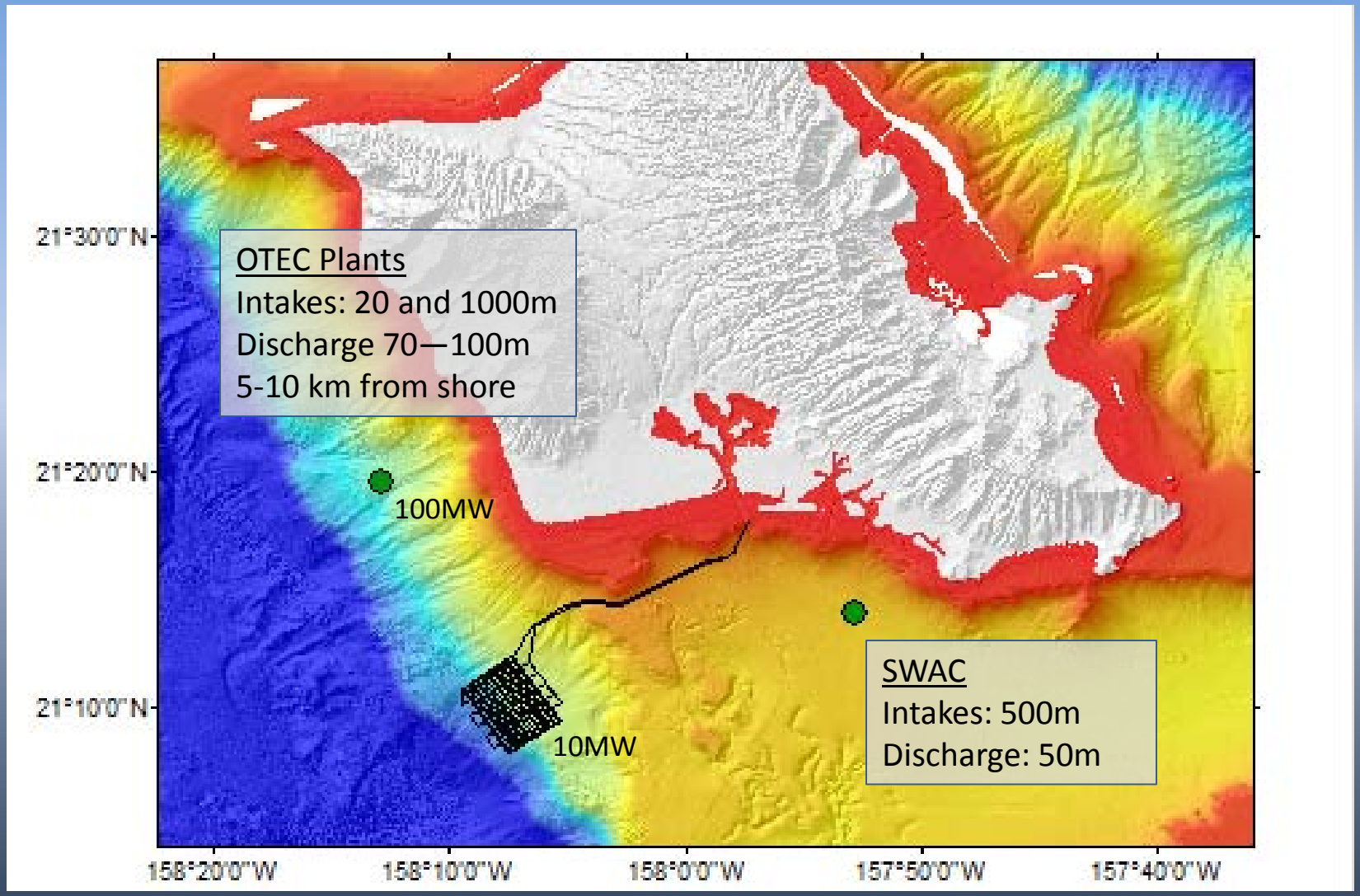


Ocean Thermal Energy Conversion (OTEC)

- Renewable energy – ocean thermal gradient
- Large water flux
  - Intakes at 20m and 1000m
  - 320-420 cubic meters /sec
  - >6 million cubic meters per day!
- Environmental impacts

*Coastal Response Resarch Center Report, 2010

OTEC development on Oahu



OTEC Environmental Impact

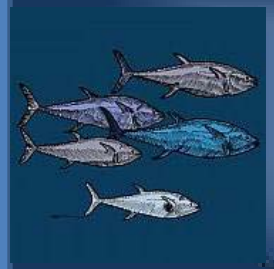
Operational Noise

Warm Water Intake:
- Entrainment
- Impingement

Biota attraction or avoidance

OTEC

Release of biocides



Cold water intake:
- Entrainment

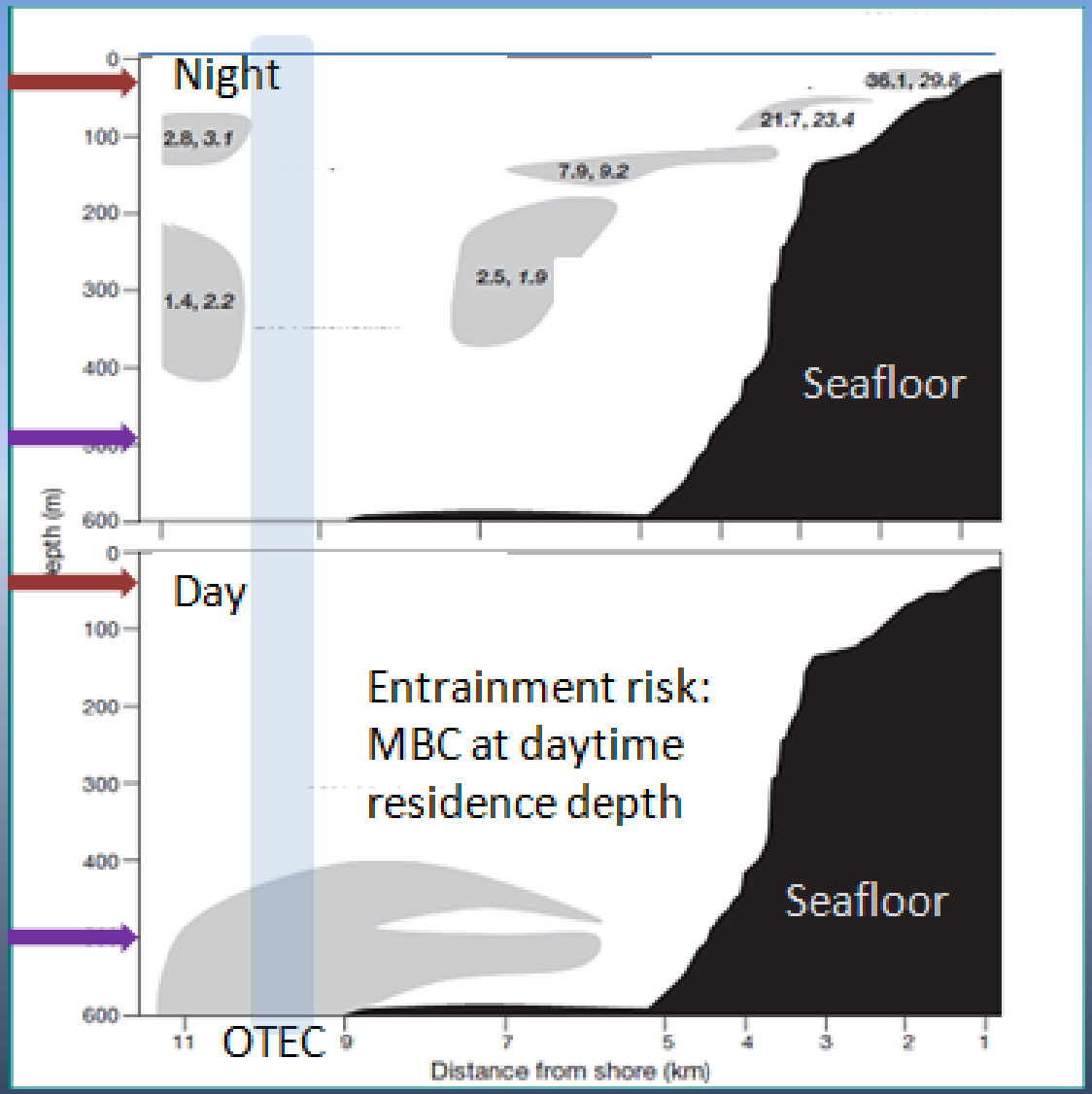
Discharge Plume:
- Redistribution of nutrients
- Secondary entrainment

Importance to fisheries

- Entrainment and impingement
  - Mortality of eggs and larvae
  - Mortality of food source for pelagic fisheries?
  - Mechanical shear, cold shock
- Plume
  - Changes in local conditions
  - Aquaculture?
  - FAD effects + enhanced productivity?

Assessing risk for entrainment and impingement

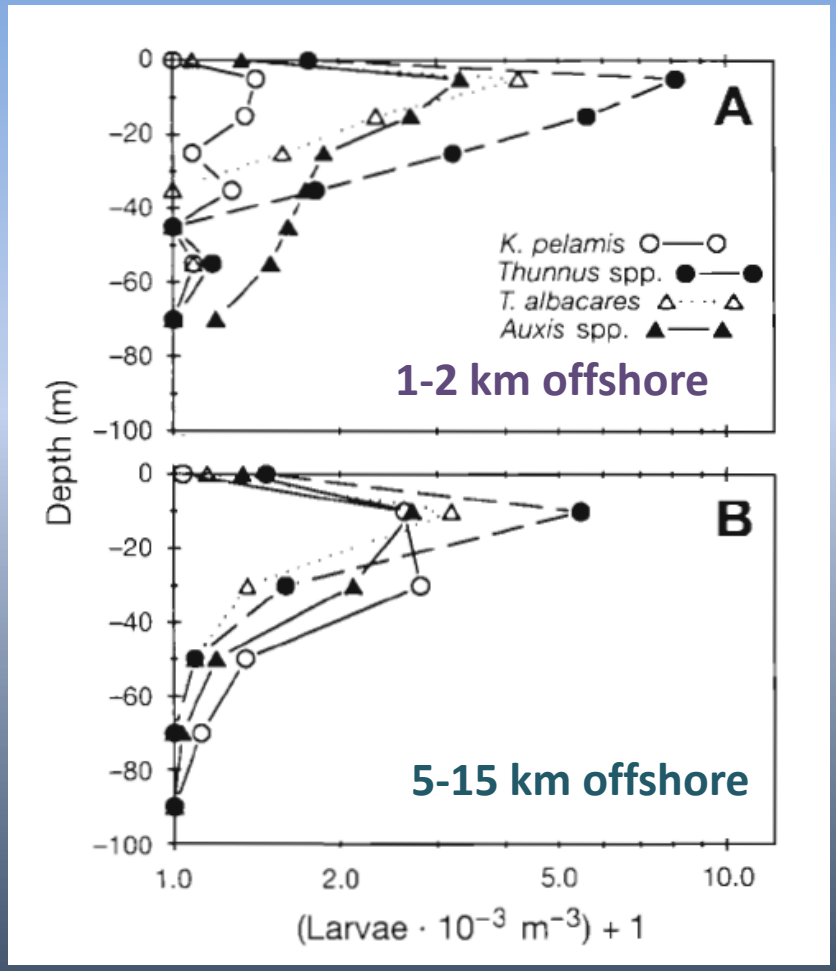
- Plankton and micronekton
  - Species present
  - 3-D distributions
  - Densities
  - Seasonal variability
- Example:
  - Mesopelagic boundary community



Benoit-Bird et al., 2006. Mar. Ecol. Prog. Ser. 319:1-14.

MOCNESS surveys on leeward Oahu: Scombrids

Tuna larvae offshore of Oahu



- Entrainment risk:
  - *T. albacares* more abundant nearshore
  - *K.pelamis* more abundant offshore
- Calculation:

  1-4.4 million larvae entrained per month for both skipjack and YFT

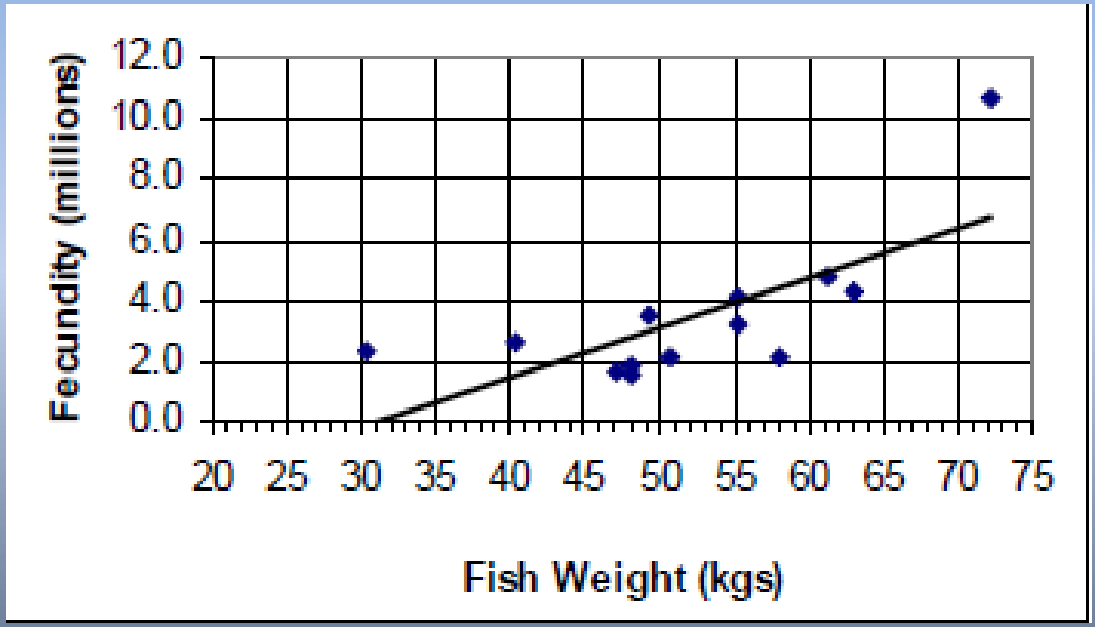
- Alarming at first glance!
- Consider tuna reproductive biology

Boehlert and Mundy 1994. Mar Ecol. Prog. Ser. 107:1-13

Yellowfin Reproductive Biology

- Spawning frequency
  - Hawaii: 1.02-1.24 days
- Batch fecundity
  - 2-10 million (Hawaii)
- Seasonality
  - June-August

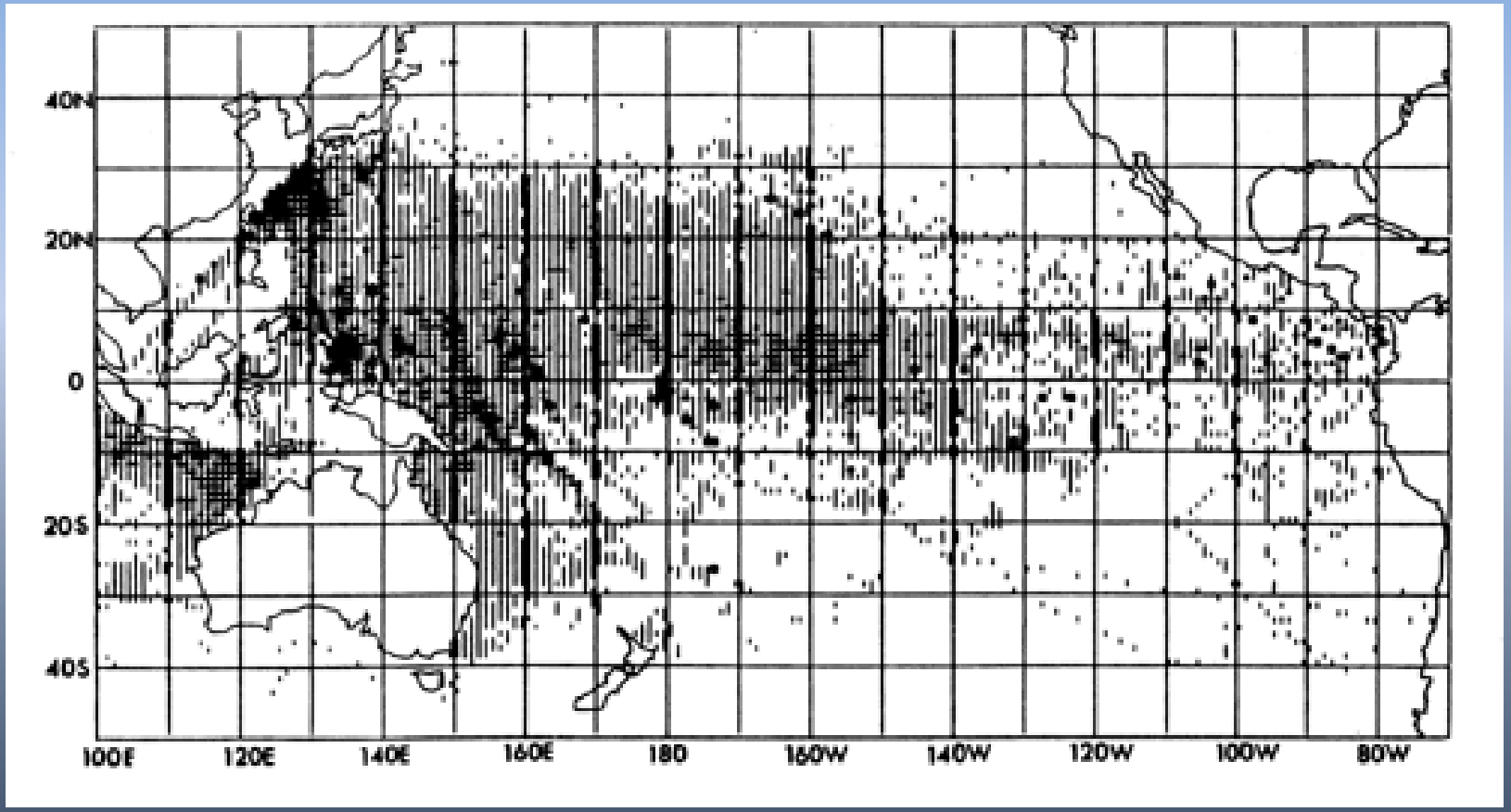
YFT Fish Weight vs. Batch Fecundity - Hawaii



Itano, JIMAR Contribution 00-328

Yellowfin Reproductive Biology

Larval YFT in Pacific Ocean



Suzuki, 1991. FAO Technical Paper, after Nishikawa et al., 1985.

MOCNESS results: other species

- Mahimahi, swordfish, billfish
  - Rare in NMFS, Miller and Leis studies
  - Sampled from neuston off Kona

- Ono
  - Collection of larvae rare in HI

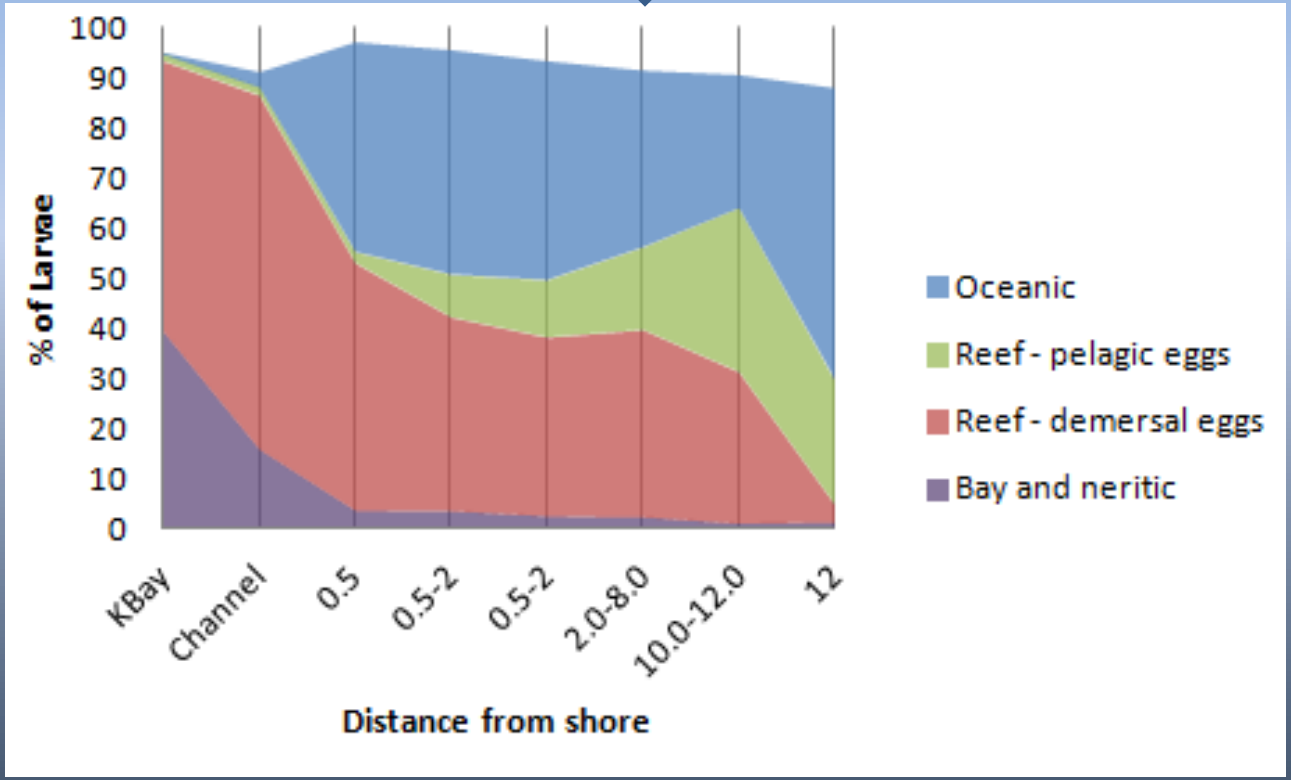
http://nationalgeographicstock.com

- Reef fish
  - Mostly inshore
  - Offshore families:
    - Labridae, Parapercidae, Serranidae, Gobiidae, and Carangidae
    - Smaller spatial scale for population

Boehlert and Mundy, 1986. NOAA Technical Report NMFS
Hyde et al., 2005. Mar. Ecol. Prog. Ser. 286:269-277.
Clarke, 1991. NOAA Technical Report NMFS.

Distribution of Reef/Oceanic larvae

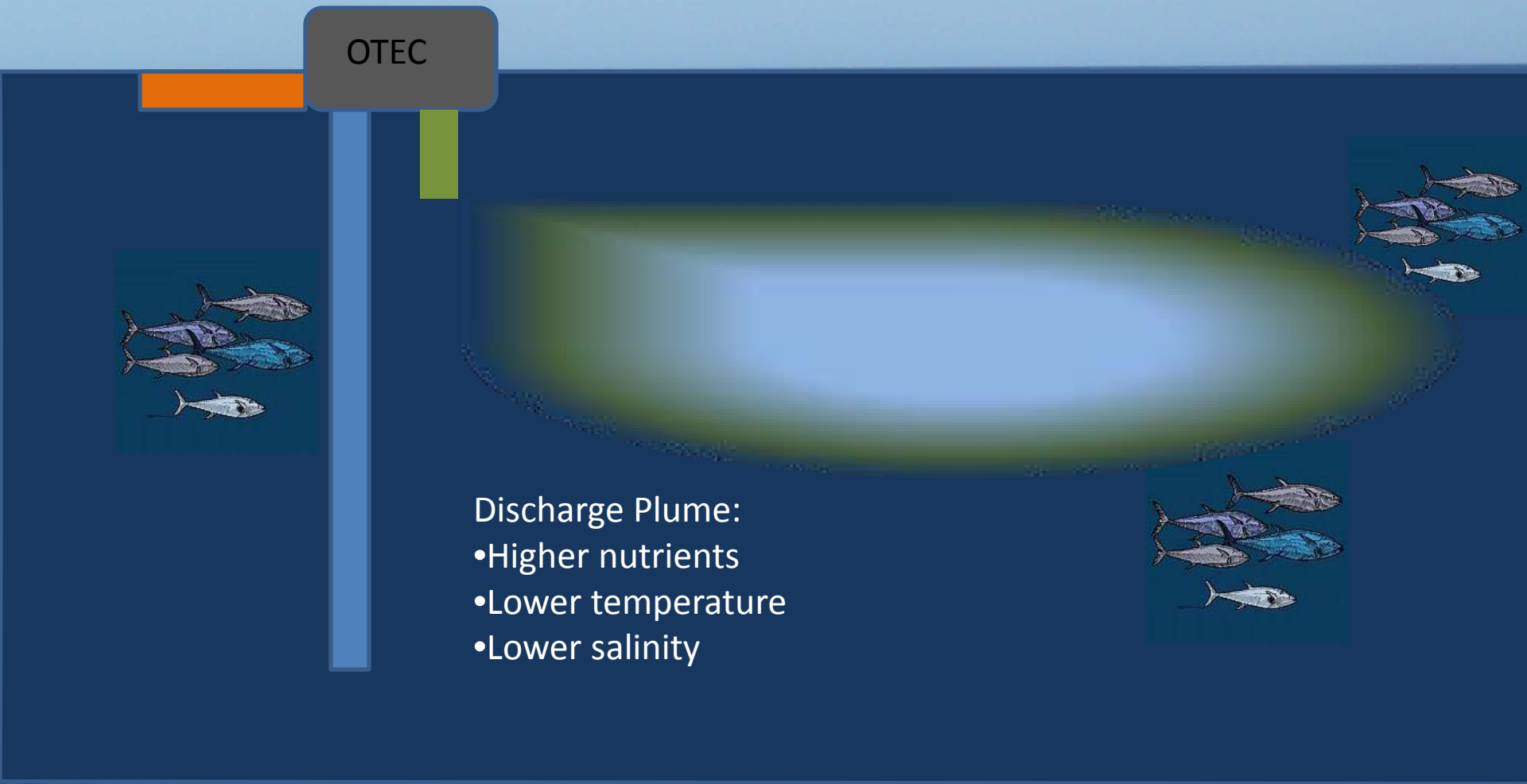
Offshore OTEC



Leis and Miller, 1976. Marine Biology. 36:359-367

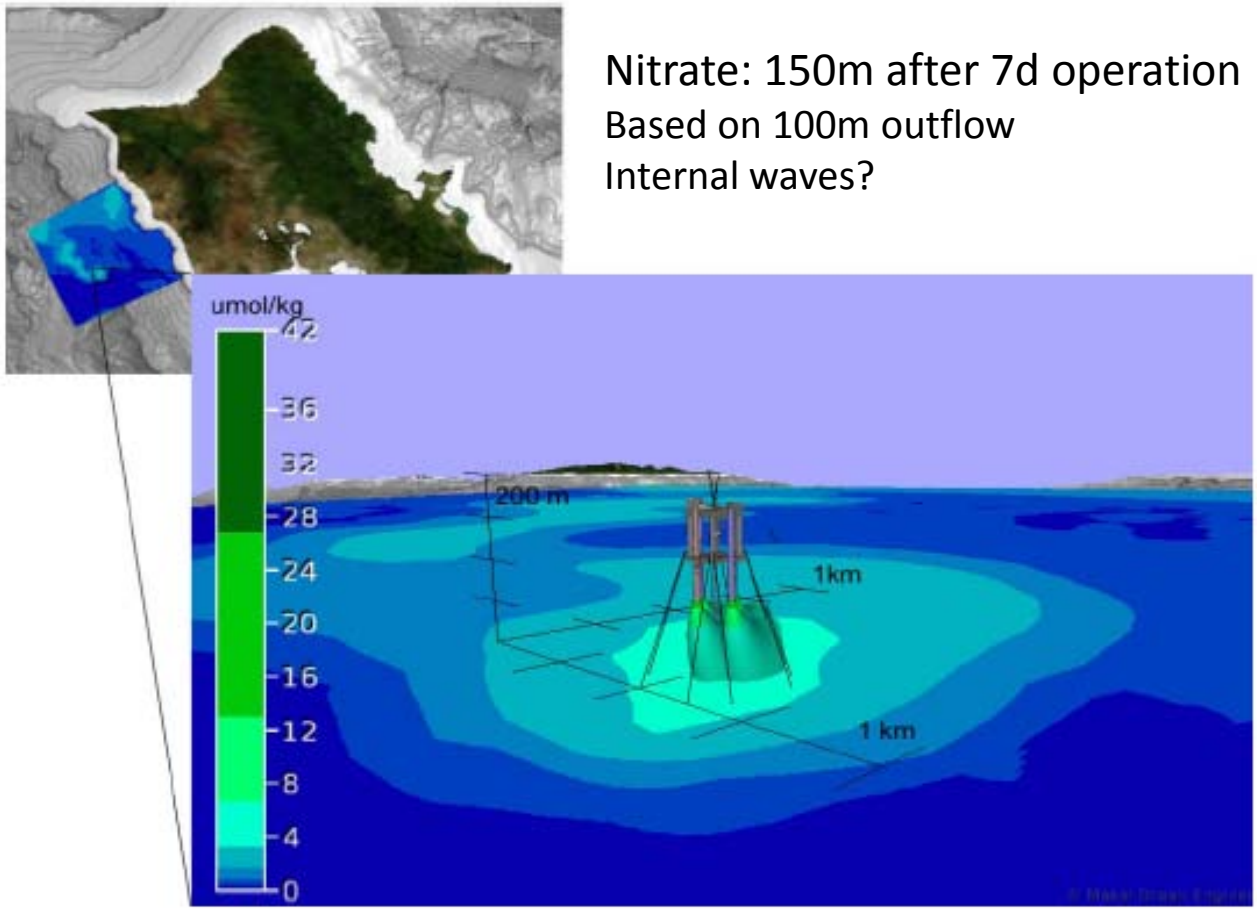
Plume: alteration of local conditions

Additional productivity?
Aggregation of fish downstream?



Discharge Plume:
- Higher nutrients
- Lower temperature
- Lower salinity

Plume Modeling: Makai Engineering

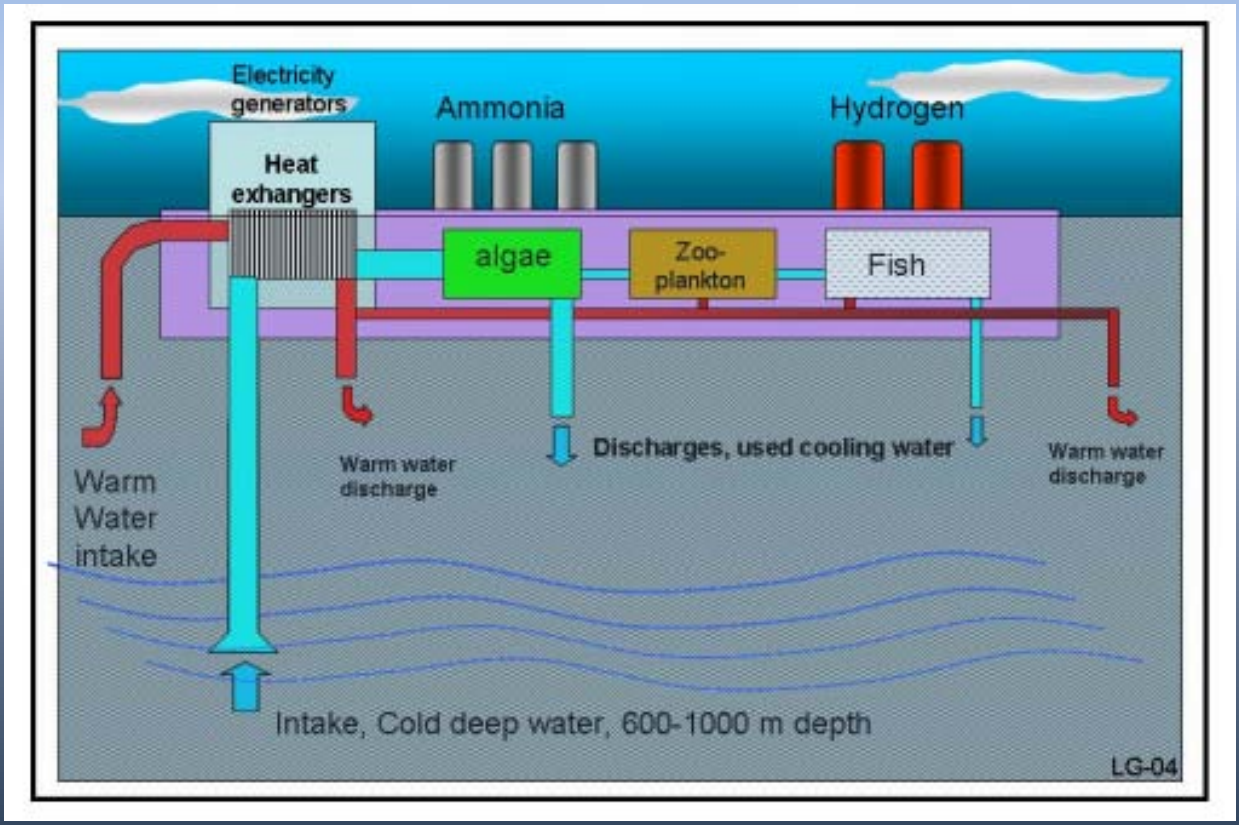


Nitrate: 150m after 7d operation
Based on 100m outflow
Internal waves?

Makai Engineering, 2010. Optimizing OTEC Sustainability Using a Hydrodynamic Modeling Tool

Plume and enhanced productivity

- "Next generation fisheries"
- Aquaculture based on upwelled nutrients



BIG ISLAND ABALONE HAWAII

HIGH HEALTH AQUACULTURE

Golman et al., 2005. WREC.

Challenges and Gaps in Knowledge: OTEC and Fisheries

- Fishing and protected species management: OTEC as a FAD
- Ecosystem level impacts of entrainment/impingement
  - Numbers of entrained organisms can be calculated
  - Recruitment, spawning area, mixing and retention…
  - Effects on populations?
- Artificially upwelled deep water
  - Enough nutrients for effective aquaculture at sea?
  - Would it have significant ecosystem impacts in higher trophic levels?

Conclusions

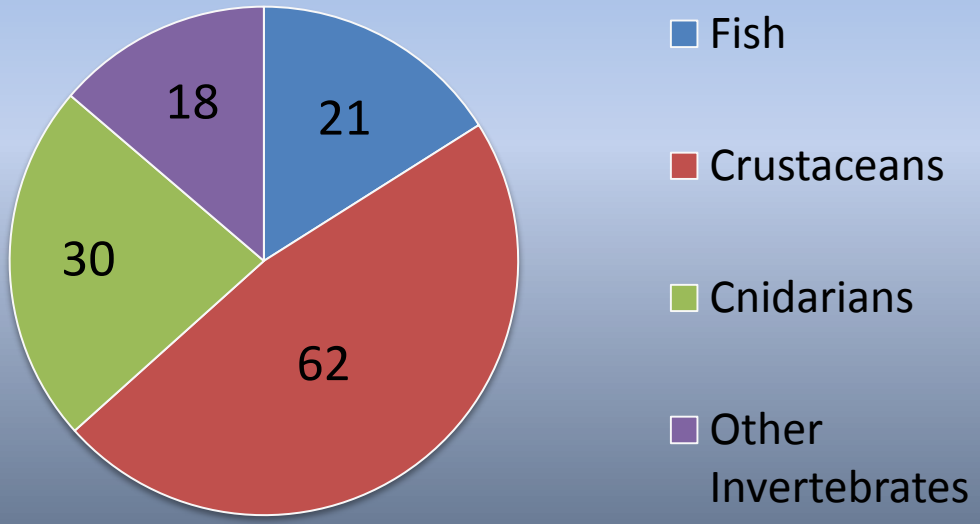
- OTEC's operation will unavoidably affect pelagic fish…
  - Noise and water pollution
  - FAD effects
  - Entrainment and Impingement
  - Effects of altered stratification and nutrient concentrations
- Significance?
  - Aggregation, upwelling nutrients
- Pilot plant: 5-10MW test facility, 1-2 years operation
  - Monitor rigorously
  - Experiment to look at potential ecosystem effects

Thank you!

Questions?

Entrainment: Cold Water Pipe

Informal monitoring:
NELHA deep water pipe
2 months, 2009



Flow rate of 0.8m^3/s

Compare to pilot plant: 25m^3/s

and commercial plant: 320m^3/s

West Hawai'i Explorations Academy