How does heated water and increased turbidity resulting from the San Onofre Nuclear Generating Station (SONGS) affect the mortality of kelp forest colonies?

This is of interest because kelp forests are a place of high diversity and act as shelter, feeding grounds, reproductive sites, fish nurseries, and settlement sites.
Background Information

- Thriving, healthy kelp beds composed of mostly *Macrocystis pyrifera* were located directly adjacent to SONGS.
- Due to an increase in heated water expulsion from the diffused pipe the neighboring kelp beds have dramatically decreased.
- This has significant ecological effects, as kelp beds kelp forest attract many species of coastal fish and invertebrates which depend on this underwater habitat for shelter and food.

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Background Info Cont.

- The San Onofre Nuclear Generating Station (SONGS) is jointly owned by Southern California Edison (SCE) (78.21%), San Diego Gas & Electric (20%), and the city of Riverside (1.79%). Today, SONGS generates approximately 2,200 megawatts of power, enough to serve 1.5 million average Southern California homes at a point in time.
- The diffused pipe running from the turbines of SONGS periodically expels heated water into areas of high kelp density. Over the course of one day this water accumulates to be on average 400,000 liters.
The pattern that was observed was that the kelp forests seemed less abundant near SONGS. The diffused water pipe that expelled water into the ocean had less cover than kelp forests farther up the coast.
Goals

- To determine if the water forced out into the ocean by the SONGS pipe is causing the mortality rate to increase in giant kelp forests.
- To determine whether or not mortality is increased due to the effects of the hot water, turbidity, or a combined synergistic effect.

Hypotheses

- General Hypothesis 1: Heat released from the piping is the cause of increased mortality of *M. pyrifera*.
- Null Hypothesis: There is no correlation between increased mortality and higher water temperatures.
- Specific Hypothesis 1: If the heat released from the piping raises the water temperature above 35°C, then the mortality of *M. pyrifera* will increase.
- Specific Hypothesis 2: If heated water is continuously released from the pipe, then *M. pyrifera* will go through complete apoptosis.
- General Hypothesis 2: Turbidity resulting from exertion force of the piping is the cause of increased mortality of *M. pyrifera*.
- Null Hypothesis: Increased turbidity does not have an effect on the mortality of *M. pyrifera*.
- Specific Hypothesis 3: If 70% of light is blocked at the surface due to upwelling, then mortality of *M. pyrifera* will increase because of inability to photosynthesize.
- General Hypothesis 3: The combined effects of heated water and turbidity from the diffused pipeline increase mortality of *M. pyrifera*.
- Null Hypothesis: Both heated water and turbidity do not result in an increase in mortality for giant kelp forests.
- Specific Hypothesis 4: If water temperature reaches above 35°C and light penetration is reduced to 30%, then there will be an increase in mortality of *M. pyrifera*.
Methods

- In all 4 of the experiments 2 water tanks will be used each containing 5 transplanted samples (10 total) of *Macrocystis pyrifera* taken from San Onofre.
- One tank will represent the control (no piping with a sediment layer at the bottom) and the other will house a two diffused pipe system similar to SONGS scaled down to size.

Methods cont.

H1 Experimental Design
- Place 5 transplants of *M. pyrifera* into the diffused tank (no sediment) and 5 in the control tank.
- Pump heated water for 2 hours until temperature reaches levels above 35°C.
- At the end of the 2 hour heating period record density of the kelp.
- Repeat 12 times to mark a 24 hour day.

H2 Experimental Design
- Place 5 transplants of *M. pyrifera* into both tanks with no sediment in the heated tank once again.
- Continuously pump heated water with no temperature barrier for a 24 hour period.
- Record density every 2 hours.
Methods cont.

**H0 Experimental Design**
- Place 5 transplants into both tanks each with a San Onofre sediment layer.
- Pump non-heated water every 2 hours into the piping tank until sediment covers 70% of the *M. pyrifera*.
- Record the density after the 2 hour pumping period.
- Repeat 12 times to mark the 24 hour day.

**H0 Experimental Design**
- Place 5 transplants into each tank each containing a San Onofre sediment layer.
- Pump heated water through the pipe for 2 hours until a temperature of 35°C is reached and sediment upwelling covers 70% of the *M. pyrifera*.
- Record the density at the end of the 2 hour period of time.
- Repeat 12 times to mark the 24 hour day.

Predicted Results

- **Specific Hypothesis 1**: Fail to reject null hypothesis if mortality does not increase due to heat stress.
  - Reject null hypothesis if mortality increases due to heat stress

- **Specific Hypothesis 2**: Fail to reject null hypothesis if *M. pyrifera* does not go through apoptosis.
  - Reject null hypothesis if *M. pyrifera* goes through apoptosis completely
Predicted Results

- **Specific Hypothesis 3**: Fail to reject null hypothesis if mortality does not increase due to an increase in turbidity.
- Reject null hypothesis if mortality increases due to an increase in turbidity.
- **Specific Hypothesis 4**: Fail to reject null hypothesis if the combination of heat and turbidity does not cause an increase in mortality.
- Reject null hypothesis if mortality increases due to the combination of heat stress and increased turbidity.