Discussion of Experimental Design Process

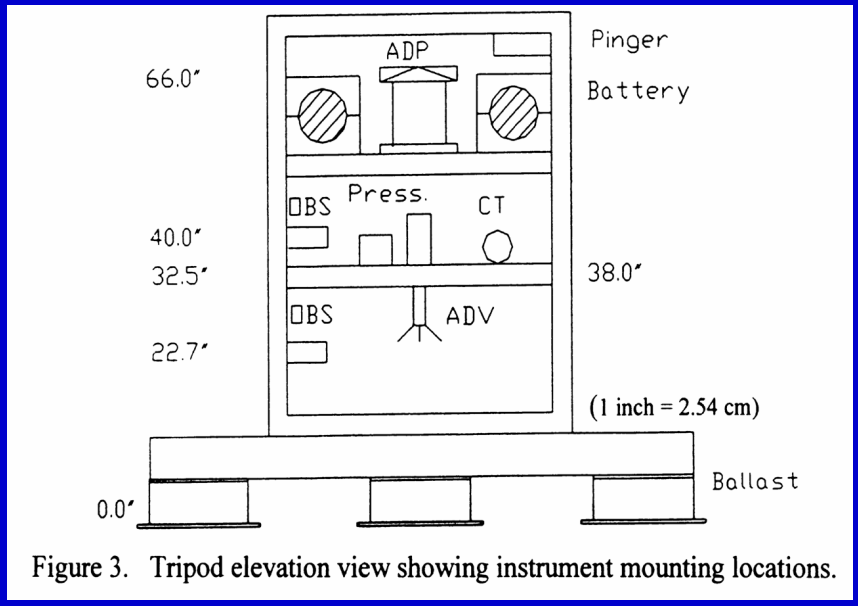


Figure 3. Tripod elevation view showing instrument mounting locations.

- **Main Project**: Effect of Offshore Dredge Pits on Shoreline Change
- **Sub-Project**: Effect of USACE Instrument Cage on Wave Climate off the Columbia River Mouth

General Definition

All the tasks required for an engineer to complete prior to the first run of a proposed experiment that ensure relevant and accurate conclusions.

Key Steps

- Literature review
- Determination of an appropriate scale
- Derivation of numerical model
- Design and construction of actual experiment

Literature Review

- Role of literature review in an experimental design is to see where proposed experiment stands in history of topic to be explored.
- Verification of past case studies and laboratory experiments and subsequent analysis of their conclusions and results.
- For a literature review to be truly useful in aiding an engineer in designing an experiment it must be thorough and objective.

Literature Review for Erosional Hot Spots

- Spanned a total of seven papers before it was decided that there was enough information to begin designing experiment.
- Papers dealt with offshore dredge pits and their resulting effects on nearby shorelines.
- Covered wide range of wave climates, beach conditions, and pit characteristics.

Effect of Pits on Shoreline Change

- Pits cause the shoreline leeward of the pit to accrete while eroding the shore just outside the edges of the pit.
- Caused by transformation of waves as they pass over pit resulting from sudden change in depth.
- Resulting shadow zone lasts for 5 wavelengths.
  - Shadow zone is defined as the region shoreward of pit where waves are still diffracting and refracting and have not returned to a uniform equilibrium state.
  - If shoreline is further than 5 wavelengths away from pit then it will have no effect on shoreline.

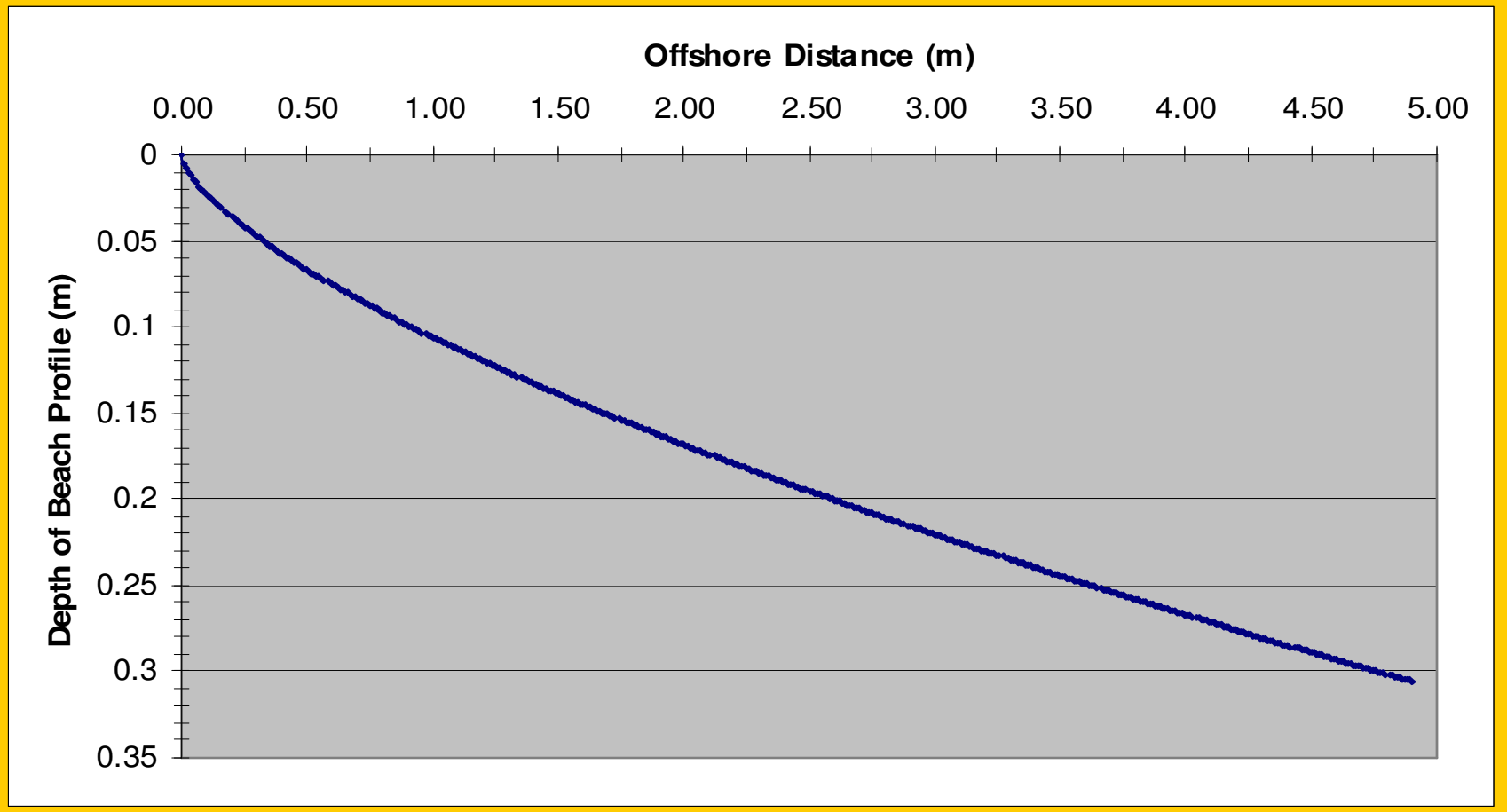
Determination of Appropriate Scale

- data from field studies and final scaling used in any past laboratory experiments are used to verify that proposed experiment is modeling relevant wave characteristics and beach conditions.
- Scaling starts with most restrictive parameter.
- Results in compromise between all relevant parameters.

Scaling Process for Erosional Hot Spots

- Restrictive parameter was ratio between water depth of surrounding sea bed to total water depth inside pit.
  - This ratio had an average value of 0.8 for case and lab studies.
- From here a suitable sediment size was determined.
  - Had to be small enough to not model unrealistically large field grain size but not so small as to make it prohibitively expensive.
- Ideal grain size of 0.22 mm was decided upon
- Equilibrium beach profile shape was calculated and plotted with data given by Dr. Robert Dean.

Equilibrium Beach Profile for D_{50} = 0.22mm



Scaling Process for Erosional Hot Spots (cont.)

- With water depth ratio and beach profile shape determined, it was now possible to place pit in the modeled beach.
- To do this, the wavelengths capable of being produced by the wave generator had to be determined.
  - It was decided that a maximum kh value of 1.0 was needed.
- It was determined that a period of 2.0s with a wavelength of 1.53 meters and a kh value of 1.01 was the best match for the experimental criteria.

Table of calculated wavelengths and associated kh values for entire effective period range of wave generator.

h (m)	0.245										
T (s)	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75	3.00
L_0 (m)	0.39	0.88	1.56	2.44	3.51	4.78	6.25	7.90	9.76	11.81	14.05
L (m)	0.50	0.73	0.93	1.10	1.26	1.40	1.53	1.65	1.76	1.86	1.96
k (1/m)	12.6	8.63	6.76	5.69	4.99	4.49	4.11	3.81	3.57	3.37	3.20
kh	3.09	2.11	1.65	1.39	1.22	1.10	1.01	0.93	0.87	0.82	0.78
Y_{pit}/L	7.07	4.83	3.79	3.19	2.79	2.51	2.30	2.14	2.00	1.89	1.79

Final Scales

- Field data suggest a good period to model would be 18 seconds.
  - Therefore, with a 2 second lab wave, a time ratio of 1:9 was established.
- Length ration is the square of the time ratio according to Froude consistency.
  - L_r = 1:81.
- The resulting pit parameters are given in the table below for two different long shore pit dimensions:

	a (m)	b (m)	D_{bed} (m)	d_{pit} (m)	V (m^3)	Y_{pit} (m)
lab (a=1L)	1.3	1.3	0.245	0.06	0.10	3.52
field	102.0	102.0	19.82	5.0	5.16E+04	285.1
lab (a=2L)	2.6	1.3	0.245	0.06	0.19	3.52
field	204.1	102.0	19.82	5.0	1.03E+05	285.1

Instrument Cage Scaling Process

- Limiting factor determined to be water depth.
  - Cage will be deployed in approximately 30 feet of water.
  - Ideal water depth in 2-D flume is 10 feet.
  - Result: 1:3 scaling
- Provides largest possible model to minimize distortion due to mismatching Reynolds number.
  - Reynolds number consistency is important for this experiment because its main goal is to determine effect of instrument cage on the eddies created by the fully turbulent flow caused by wave action.

Derivation of Numerical Model

- End purpose of experimental process is to test a new numerical model that may demonstrate previously undiscovered phenomena.
- A numerical model is a computer driven mathematical model that is used to predict changes in the coastal environment.

Dredge Pit Numerical Model

- Numerical model for dredge pit experiment has not yet been completed
- David Michalson is currently working on it with Dr. Merrick Haller.

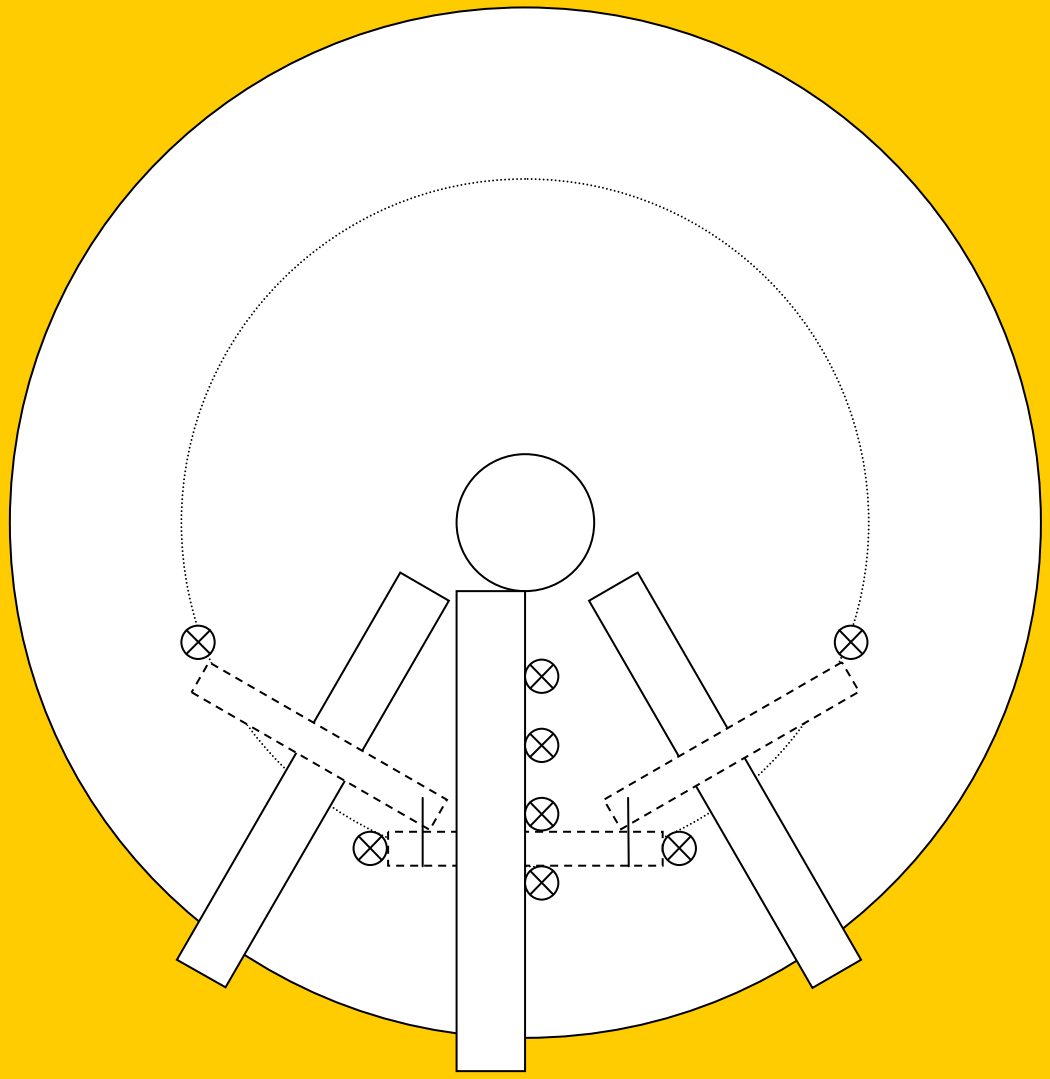
Design and Construction of Actual Experiment

- Ensure that all experimental equipment is in working order.
- Construct any models and gauge mounting apparatuses to be used.
- Mount all gauges and sensors in required locations.
- Facilitate cohesive setup of all individual elements with a data collection system to form a controlled, fully monitored experiment.

Construction of dredge pit model gauge mounts.

- The geometric properties of the basin made task challenging since it is difficult to mount gauges in a radial and circumscribed fashion.
- This problem was solved by constructing two 20 feet long cantilevered 4x4 beams that extend inward from outer edge of basin 16 feet and point to the center of wave generators.
- It is planned to mount an eight feet long 2x2 to each cantilevered beam so that a third 2x2 can be attached to inner end of each beam. This will result in half of a circumscribed hexagon that will allow four wave gauges to be mounted in line with an imaginary circumscribed circle for long shore measurements.
- 4 wave gauges mounted to wave generator walkway to record cross shore wave data.

Diagram of Planned Wave Gauge Mounting Apparatus



Model Construction for Instrument Cage Experiment

- Main body constructed of 1” angled aluminum.
- Triangular base made from two 2” channel piece bolted together back to back.
- Feet made from concrete poured into 6” diameter molds.
- Entire model painted flat black so that light would not reflect off of aluminum and interfere with turbidity measurements.

Turbidity Meter Calibration

- Prepare ten 30 g samples of sediment
- Add samples one at a time to ten liters of water in a black bucket stirring between each sample with a drill powered paint stirrer.
- Resulting voltage readouts are recorded and plotted against the known sediment concentration in g/L.
- Calibration process also allows for gain to be adjusted.
  - Data is not lost due to gain being set too high.
  - Optimal data resolution obtained by ensuring that the gain is not set too low.

Summary

- The dredge pit experiment gave me experience in researching and experimental design process.
- The instrument cage experiment gave me experience in building a scale model and calibrating a typical coastal engineering sensor (OBS turbidity meter).
- Although I did not get to perform an actual experiment, I still learned a lot and am now more prepared to tackle the challenges that lie ahead for me in graduate school.
- Being responsible for two experiments forced me to budget my time effectively and prepared me for a job in the real world where I will be expected to handle more than one project at once.

Questions…