ESP Mooring Analysis for Catalina Island Deployment

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The ESP deployment at Catalina Island is to be in deeper water than has previously been done with the current mooring design. This report outlines analysis performed on the existing mooring design in a range of water depths. The analysis performed has used "WHOI-Cable" to numerically model the behavior the mooring in a range of conditions. Due to the expected mild sea states at this location, the analysis has concentrated on the static behavior of the system (i.e. it's response to wind and currents) and only sample computations have been performed that include wave forcing and the resulting dynamic forces in the system.

Location

The primary site is on the north-east side of Catalina Island at 33.484 deg N/ 118.5388 deg W. The alternative site is nearby at 33.4775 deg N/118.5133 deg W.

There have been some discrepancies in the reported depth at the primary location, ranging from 90m to 200m. The NOAA charts indicate a depth of about 150m, with a mean bottom slope of about 12 degrees. The analysis run below is for depths of 50m, 100m, 150m, and 200m to cover the range and allow comparisons with deployments at shallower depths where there is more experience with the system.

Environmental Conditions

The currents at this location are not well characterized; the best estimates that have been found are from HF radar data collected by SCOOS over the past several years. The radar installations that cover this area spend a lot of time down so the data is spares. Nevertheless surface currents above 0.75 m/s have not been observed. Plots attached below show the data availability, histograms of the observed surface currents at the primary and alternative sites.

There are no current profiles available at this location, for the analysis two profiles have been assumed, a linear case in which the specified surface current decays linearly to zero at the bottom, and a constant current profile in which the current is constant throughout the water column. This later is considered an estimate of the worst case (although presumably the subsurface currents could be greater than the surface currents…).

Mooring Design

The mooring design is the same as has been deployed many times in shallower water and consists of a floated EM cable to a small submersible float above the instrument, a compliant "shackle" element below the instrument, and polyester rope down to a deadweight anchor. Traditionally a 7/8" polyester

rope has been used but is overkill in terms of strength. For these analyses this element has been reduced to 5/8" diameter to reduce current loading. The 5/8" size has a breaking strength of 13,900lbs which is plenty of strength margin compared to the expected loads.

Mooring Modelling

The mooring behavior has been simulated by constructing a numerical model using the "WHOI-Cable" modelling software. The attached documentation shows the node arrangements for this finite-difference solution, as well as the material properties used throughout. Due to limitations in the software, the ESP instrument, mounting platform, and associated "bail" is not well modelled and therefore the details of this devices positions and motions are not characterized in detail, but the net effect of the instrument on the mooring position should be acceptable.

Numerical Results

Static Results

The static results across a range of current profiles and depths are presented in the attached plots. The "buoy freeboard" shows the point at which the surface expression submerges for each depth and current profile. Also shown are the ESP instruments depth and the resulting forces on the anchor, tension in the shackle (and polyester rope), etc.

Dynamic Results

A single dynamic analysis was performed as an example for the 150meter mooring in 0.5m/s linear and waves with a 4 meter significant wave height and peak period of 10s. This was selected based on the assumption that the sea conditions inside of Catalina will remain relatively mild. The peak tensions in this case were less than twice the mean tensions and the time domain record of these forces are shown in a figure below.

Conclusions

In the worst case expected current conditions (Constant current profile of 0.75m/s extending down to 200m), the surface buoy is likely to be on the verge of submerging and the ESP instrument itself will be at depth of 20m (down from 7m in calm conditions). Mooring tensions at the anchor in this condition will be about 350lbs, evenly split between horizontal and vertical forces.

Dynamic loads due to wave forcing have not been carefully characterized in this study but an estimate is that the peak loads in the system will be about 2 times the static loads, still well below the strength of the materials used throughout, but high enough that the anchoring system will need to rely on being stuck in the mud to keep from dragging .