MOOS MOORING RISER FLOATATION SPECIFICATION
Revision 2.0

1.0 INTRODUCTION

The Monterey Bay Aquarium Research Institute (MBARI) is currently developing a deep ocean underwater science observatory. The maximum installed depth of the observatory is planned to be 4000 meters deep in seawater. The observatory design includes a wave following buoy system connected to a seafloor anchor with a synthetic electro-optical cable strength member referred to as the **Riser Cable**.

The mooring is a reverse catenary mooring that relies upon floatation attached to the riser cable to form an S-shape in the riser that provides the required geometric compliance in the system (See figure 1).

In December 2002, a prototype mooring was deployed and unfortunately broke free after 11 days of service. That system employed 20 discrete floatation elements, of approximately 30 lbs buoyancy each, distributed approximately every 50 meters. The riser cable failure has since been attributed to repetitive bending of the cable at the attachment point of the floatation elements, where an insufficient bending strain relief was used.

We are now working to develop and qualify an improved floatation system that will provide the needed buoyancy to the cable without damage. Instead of the discrete float system, the system is being re-designed to incorporate only one floatation location, with sufficient bend-restriction and bending strain relief at that location to ensure the cable is not stressed beyond its mechanical specification.

This document outlines the design concept, the expected bending conditions seen at the float location and specifies the requirements that the new design must meet. Two mooring systems are to be built and deployed in March '04. These two systems will be the same in every way except for the riser cable itself. The cable constructions will differ but will be similar in weight and diameter.

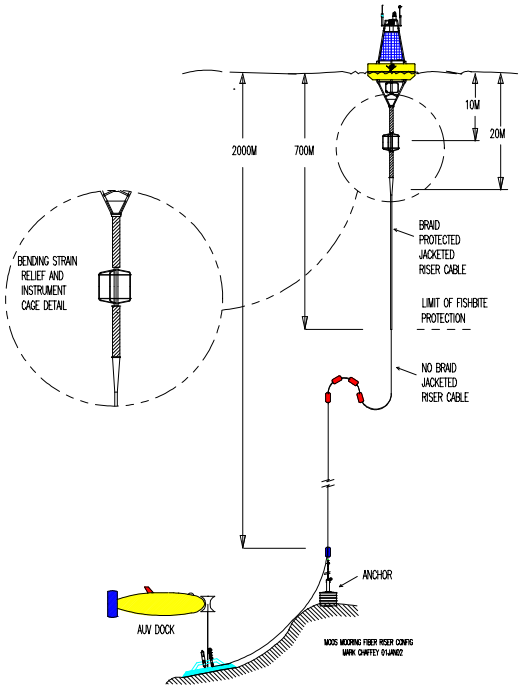

Figure 1: MBARI MOOS mooring system

2.0 FLOAT/BEND RESTRICTOR DESCRIPTION

Although Figure 1 shows the floatation as discrete elements, the intention of the new design is to incorporate all the floatation into one item that is relatively short (3-5 meters), See attached figure 2. It is envisioned that this floatation element acts as a bend restrictor that cannot bend tighter than a multiple of the cable minimum bend radius. At each end of the bend restrictor, a bending strain relief will be required to ensure that the cable does not bend sharply at the end of the bend restrictor. This bend restrictor/floatation element must be clamped sufficiently to the cable so it does not move upward during deployment or service. Furthermore, the system must be installable on the cable as the cable is payed out during an anchor-last mooring deployment. Figure 2 illustrates the system and provides details about the desired placement of the floatation element on the cable. The cable specifics themselves are not known exactly at this point, but the following table provides nominal values for the cable diameter and weight in water.

Nominal Cable Size:

Cable Diameter	0.9-1.1 inch
Cable Weight in Water	0.05 lbs/ft
Minimum Bend Radius	20 inches

In order to achieve the placement objectives shown in figure 2, along with a minimum tension at the anchor cable termination of 150 lbs, approximately 400-500 lbs of buoyancy are required. Note: The cable termination and anchor hardware will be floated separately with attached syntactic foam and, as such, should be considered neutrally buoyant for purposes of calculating the buoyancy required to provide 150 lbs of tension at the cable termination.

3.0 LOAD CONDITIONS

The bend restrictor portion of the floatation element will straighten out during high loads on the riser cable (predicted to remain below 4500lbs) and will be allowed to assume a curved shape during calm conditions when tensions drop to near zero. Bending strain reliefs are needed at the ends of the bend restrictor to maintain the minimum bend radius in the cable. Figure 3 (attached) shows the expected tension vs. bend angle relationship at this location as found from a dynamic analysis of the riser cable. In this figure, the red points indicate the 5% most severe conditions, the green points are the 5% least severe conditions and the blue points indicate the most common conditions that exist 90% of the time.

4.0 FLOATATION SYSTEM REQUIREMENTS

- The floatation system shall induce the riser cable into a catenary and provide 150 lbs tension in the riser cable at the bottom termination.
- The bottom of the catenary shall be at least 200 meters above the sea-floor at it's lowest position.
- It must be possible to install the float/strain-relief during the deployment by clamping to the cable, without sliding anything over the ends.
- The system shall maintain a 1 meter minimum bend radius in the cable when subject to the loading conditions described in this document.
- The system must not suffer from fatigue damage.
- All elements must remain serviceable at depths of up to 4000 meters in seawater.