MTM2 Breakaway and Redeployment Report

Rev. 1.0 14JAN05 mrc

1. The purpose of this document is to capture the cause and effect of the MTM2 breakaway on the night of January 10, 2005 and the lessons learned during the subsequent towing and redeployment of the mooring January 12.
2. The time of the breakaway (PST) as shown in SSDS records (note: SIAM clock was 34 minutes fast at time of redeployment):

1105409036305	2005-01-10 18:03:56 -0800	21204	$GPRMC,013015,A,3649.7905,N,12217.1613,W,001.5,318.5,110105,014.8,E*61

3. The optical attenuation was unchanged after the breakaway indicating that the riser cable was intact down to the lower termination. Throughout the mooring drift and redeployment the mooring power system, electronics, software and communications operated normally.
4. The Pt. Lobos sailed on the second day after the breakaway and intercepted the mooring in 300 meters of water after it had drifted approximately 12nm NW. The bottom of the mooring was calculated to be approximately 10 lbs. positive with release attached or 50 lbs. positive without release. The bottom was not found on the surface. The floatation collar elements were however on the surface. “We had to lash to the float string and pull it alongside the boat, this was difficult and accomplished by pushing a float on a line under the string with a pole. When it appeared on the other side we grabbed it and had a loop of line around the float. Lifting the floats in this manner is marginal, at one point I heard two of the floats "pop" apart as we were advised they might. That float was quite near the bottom of the float string, so I'm not too worried about it” – Andy H. Using alternate lines placed under the collars were worked down and the cable was reached and placed in a proper radius stringing block (Sherman and Reilly PN) identical to the block shown in fig. 1. At first the Pt. Lobos was used to back down and work down the cable but several times the cable dropped off the sheave roller and wrapped tightly around the throat of the block. This wrap was severe enough on at least on occasion to leave a permanent “kink memory” in the cable jacket. Subsequently the cable was hand tended around the block and when it inevitably jumped the sheave, less

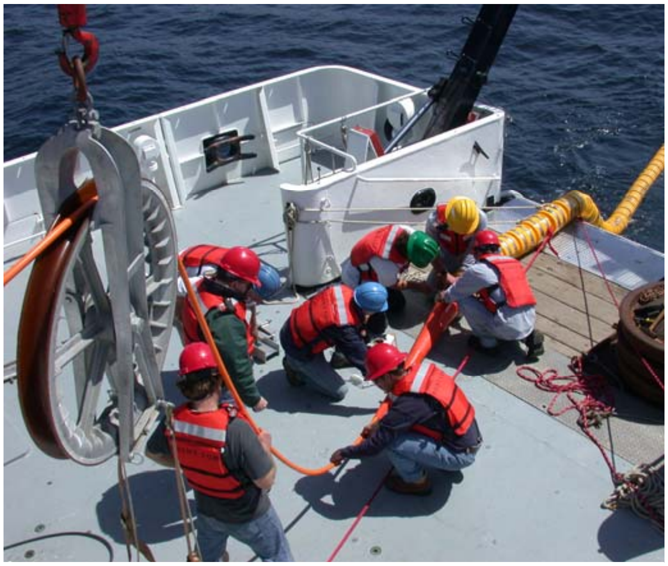

Figure 1. Illustration from deployment showing large radius snatch block.

force was exerted as it wrapped. The lower termination was reached. During the process several long areas of jacket damage were noted and at least one place had exposed Vectran strength member, as if the cable had been dragged across rough objects.

5. When the end of the riser cable was reached it was noted that the release had broken at the load cage around the acoustic transducer. Evidence suggests that at some point in the deployment the release may have become caught on or under the anchors causing a large side load on the cage. On at least one ROV dive the release was seen to be trapped under the edge of the anchor. The galvanized shackles and pins connection the load cell to the release had extensive corrosion although the cotter pins were still in place. See Figs. 2 and 3.

Figure 2. Lower termination and release at the time of deployment.

Figure 3. Load cell to release connection showing release cage failure.

6. With the end of the riser cable on deck it was noted that the ROV mate optical connector at the base of the mooring showed evidence of having been banged around, probably against the buoy anchor. An attempt was made to mate to the 4E/4SM ROV hybrid plug jumper, OCEAN DESIGN INC. DOC. NO. 57807 REV. A, but the test connector and the riser cable connector would not mechanically mate. Several checks were made as suggested by ODI but no joy. The connectors could be forced together until the two faces met but would go no further. Note: On the first ROV dive to the anchor after deployment the ROV mate connector was still secured to its deployment plate. On subsequent dives it had become partially detached and was flopping around.
7. The buoy was towed to the same approximate position as the original anchoring spot and redeployed with a new six wheel double stack anchor and a new acoustic release (single).
8. During the redeployment an optical attenuation “spike” lasting approximately 50 seconds was noted in the riser cable of approximately 3dB. This spike occurred at the same time as the Pt. Lobos began to make way towing the buoy, as shown in fig, 4. What caused this spike? The nature of the optical fibers in the JDR riser cable is such that one would expect that a sharp increase in attenuation could not occur without seriously damaging the cable. The optical fibers are protected in a Laser Armor Tech stainless steel tube about the size of a hypodermic needle. For the tube to impinge on the optical fibers it must either collapse or buckle. One would expect that this type of damage would cause

permanent changes in attenuation although we have a previous experience where the laser Armor Tech tube actually broke but two of the four fibers inside showed little attenuation increase. In addition to optical damage one can expect that handling the cable severely enough to cause fiber attenuation would most likely also cause some damage the cable strength members.

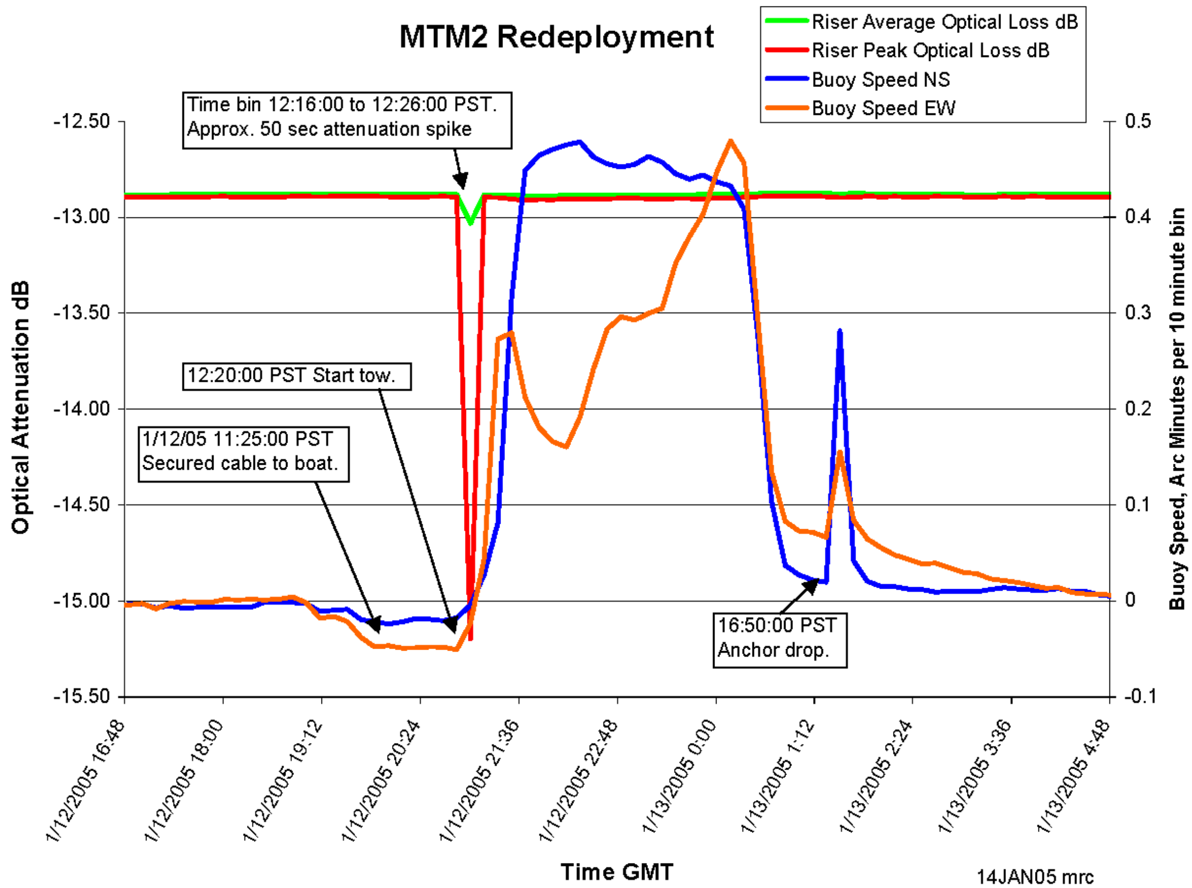

Figure 4. Redeployment optical attenuation and buoy speed.

9. The entire record of optical attenuation has been examined since deployment, and interestingly, one additional 1.5dB attenuation spike was noted on September 7, 2004, as shown in fig. 5. Examination of the record show that this happens to correspond to the day the Pt. Lobos/Ventana attached additional floatation elements to the base of the riser. The Zephyr was employed to clear the surface buoy from the dive area over the anchor site. In order to move the buoy a towline was attached to the top of the buoy tower and the buoy slowly towed. The pull of the line tension so high on the buoy caused it to cant over about 45 degrees, see figs. 6 and 7. One can speculate that with the static load of 1200 lbs. pulling down on the snubber and the buoy being pulled over sideways, at one point the snubber may have briefly kinked, causing a tight bend radius in the internal

coilcord and subsequent optical attenuation spike. This effect on the optics could be non-catastrophic and could correct itself when the kink was removed.

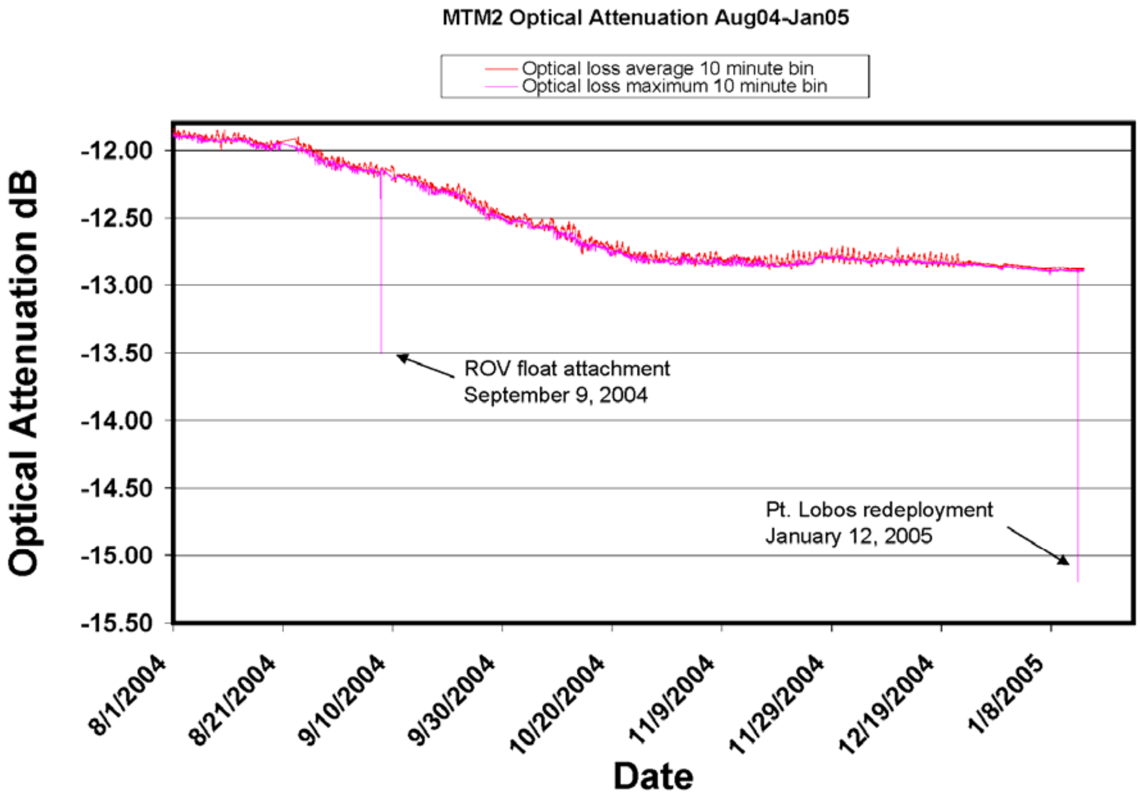

Figure 5. Optical attenuation since August 2004.

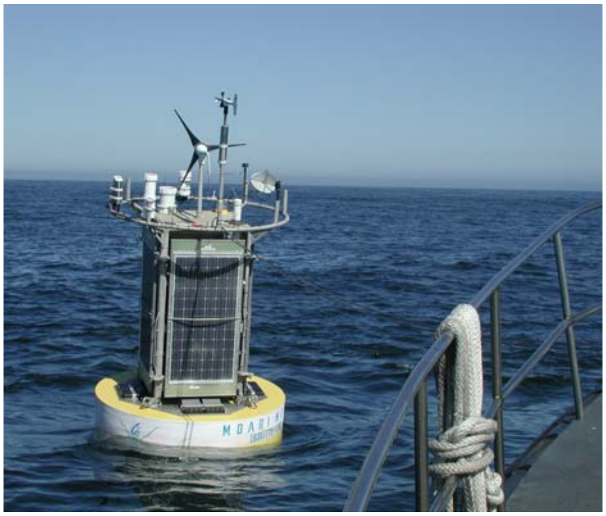

Figure 6. Towline attached to tower ring.

Figure 7. Buoy heel when towing.

10. Could the optical attenuation spike observed during the beginning of the redeployment buoy tow have been caused by the snubber kinking at the base of the buoy as the riser cable came up tight? This is a possible cause, although no subsequent spikes were noted

during the tow. Two lessons can draw from this: 1. Perhaps the snubber construction should have additional reinforcement at the flange end bolted to the base of the buoy. This short section most likely sees the most severe repetitive bending of the entire assembly. 2. Towing the buoy in such a way as to cause a large heeling angle when the snubber is tending straight down is probably not the best method as it may be causing a kink in the snubber hose under the buoy is some conditions. If this was not the cause of the attenuation spike and instead the riser cable itself was the cause then the riser cable is likely to be permanently damaged.

Lessons Learned from the Loss and Recovery

(mostly from Andy H. with additions from Mike K., Steve E., and Mark C.)

1) Tool and equipment modifications (more detail below):
    a. Die grinder guide (and air or battery powered grinder?) for removing float clamps.
    b. Lower termination optical cable whip should be field replaceable.
    c. Need method of stopping cable that will not cause damage and can be installed in less than 5 minutes.
    d. Method of being able to use trawl winch on Sur even with Dynacon installed.
    e. Better snatch block.
    f. A roller guide that can overboard cable, snubber and floats under a controlled radius.

1) The linksyn floats continue to appear durable and a good solution to attaching floatation to the cable. The split bending strain reliefs at the ends are tolerable, but not a good as those at the ends of the cable.

In the future:

a) The bending strain reliefs at the ends of the floated section need to be improved, for function and ease of installation.

b) The bending strain reliefs need an attachment point for line attachment during handling. As does the clamp section, and anywhere else where an attachment can be tolerated structurally.

2) The large diameter sheave is an accident waiting to happen. The cable jumps the sheave and then bends extremely tightly over the edge (1" bend radius). This happened several times yesterday, more than once leaving a visible kink in the cable. Not sure of the effects on the cable strength.

3) The entire bottom arrangement needs improvement. I think with the experience of the ROV dives, the deployment, and the re-deployment, we're in a good position to engineer a system which meets all needs, a quick list of requirements for this system is:

a) Sufficient floatation to float the termination without question (~ 750 lbs)
b) Designed to protect the releases and termination from the anchor.
c) stiff in axial rotation so the cable whip won't wrap around the anchor.

d) free in bending. What I mean is, the cable termination itself should be free to line up with the cable, to minimize the demands on the bending strain relief at the bottom.

e) There should be enough chain between the cable termination and the anchor to allow for easy hook-up during deployment, this requirement is at odds with the need for low rotation and easy hook-up via ROV, so a compromise is required.

f) The optical whip and load cell and connections should be field serviceable with a reasonable effort, if the connector fails, we need to be prepared to bring the termination up and swap the connector quickly (< 1hr?)

g) Possibly an integral load cell, Mike K. reports apparent damage to the load cell cable where it had been pinched, I didn't see this myself.

h) Bulletproof in general, and engineered for fatigue specifically.

Other desirable features:

a) Design amenable to syntactic foam or alternatively Benthos spheres for the cost conscious?

b) Option of redundant releases.

c) Controlled autonomous release of Benthic cable in case of riser release.

4) Before the next deployment we need a good way to "stop off" on the cable. During the first deployment we laced a Yale grip around the cable to allow enough slack to attach the floats. I believe I saw the spot this was done yesterday, the outer jacket of the cable was "wrinkled" over a length of about 6-8 inches. I only got a glance as it went by, but I'm confident that at least the outer layer of Vectran has been affected. I'm imagining a clamp design with integral bending strain reliefs. Perhaps "over-center" latches could be used to attach, I think it needs to be attachable within 5 minutes. One idea is a latch arrangement with two settings, one for hard clamping, and another that allows the cable to slide through the unit.

5) About 200m above the anchor, there were significant cuts and gouges in the outer jacket of the cable. Some cuts clearly went through the jacket, there were a lot of "ribbons" of poly-ethylene cut out of the jacket, they looked fresh, but who knows. This extended over a 20m length or so and I have no idea of the cause. I don't believe this part of the cable was damaged during deployment.