NOAA
Florida Keys National Marine Sanctuary
Dive Fatality Incident

September 5, 2008

SUMMARY—PUBLICLY RELEASABLE

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
Office of the Chief Administrative Officer
Safety and Environmental Compliance Office

FOREWORD

Federal agencies must undertake a safety investigation of all accidents resulting in a fatality. The purpose of the investigation is to assess and fix any possible shortcomings or safety issues that may have contributed to the incident. The goal is to prevent future accidents. The report relies on employee confidential and unsworn statements concerning incident causes and factors.

Distribution of safety investigation reports is limited to officials in charge of the work place, appropriate safety committees, and the exclusive representative of the employee, if any. With the exception of factual material in them, they are not releasable to employees or the general public. They are protected by Freedom of Information Act Exemption 5.

Consequently, this document has been prepared to provide a summary of the conclusions and recommendations from the incident investigation team's report. This document may be shared with appropriate employees and other parties who have a need to understand the primary conclusions of the incident investigation and the recommendations made to NOAA for action. The material that follows has been lifted essentially verbatim from the incident investigation team's report. The numbering of the recommendations has been modified to enable internal NOAA tracking of action plans.

EXECUTIVE SUMMARY

On March 17, 2008, a team from the lower region of the NOAA Florida Keys National Marine Sanctuary Office departed on the NOAA vessel PETER GLADDING on route to a dive site approximately 70 nautical miles west of Key West and 14 nautical miles southwest of the Dry Tortugas. The team's mission was to investigate suitable mooring sites for a coral restoration project. The diving mishap occurred during the last dive of the day when the third dive team was deployed to determine if the bottom conditions were suitable for installing moorings. While the two divers were probing the sea floor, Diver two (DV2) noticed he was getting low on breathing gas and alerted Diver one (DV1) of his situation. DV1 confirmed DV2's low gas reading and checked his own pressure gauge and determined that they both needed to begin their ascent back to the surface. As they ascended, both divers were calm and in control. As they reached the 15-foot safety stop. DV1 reached for the pre-staged reserve gas cylinder by reaching over DV2 for the regulator and tried to breathe from it. While opening the valve on the reserve gas cylinder, DV2 noticed that DV1 had become unconscious and was sinking towards the bottom. DV2 tried to rescue DV1 but when that failed as his own gas supply began to run out, he immediately sought emergency assistance from topside. The standby safety diver (SBSD) was immediately deployed to rescue DV1 and the SBSD descended to the bottom to retrieve DV1 from the sea floor. Once DV1 and the SBSD were on the surface, the vessel crew assisted the SBSD by lifting DV1 out of the water and onto the deck of the vessel. Cardiopulmonary resuscitation (CPR) and oxygen (02) were immediately administered and the vessel departed the dive site en route to Fort Jefferson where a medical evacuation helicopter was en route to transport the victim to the U.S. mainland. Upon arrival at the Lower Keys Medical Center in Key West, DV1 was pronounced dead by the attending emergency room physician. Over the following week NOAA's Safety and Environmental Compliance Office (NOAA-SECO) assembled an incident investigation team of diving experts from the U.S. Navy, U.S. Coast Guard (USCG), and Florida State University. A NOAA SECO safety investigator was added to complete the team selection which included the following members:

Dr. Robert Whaley, Director, Diving Programs, USN (Investigator-in-Charge)
Mr. Michael Zinszer, Director, Advanced Science Diving Program, UCSI Instructor, Florida State University
HSC Philip Roy, Assistant Dive Program Manager, USCG
Mr. Joe Duran, Occupational Safety and Health Specialist, NOAA-SECO

NOTE: Dr. Robert Whaley retired from the Navy on August 15, 2008, prior to the finalization of this report. HSC Philip Roy was named the Investigator-in-Charge for purposes of finalizing the report and responding to any questions from NOAA regarding the report.

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INCIDENT NARRATIVE

On or about 0900, on March 17, 2008, eight personnel aboard the NOAA vessel PETER GLADDING, left the NOAA Florida Keys National Marine Sanctuary (FKNMS) facility in Key West, for a preserve approximately 14 nautical miles (nm) southwest of the Dry Tortugas. Their mission was to investigate suitable mooring sites for a coral restoration project. Six of the personnel would make up three 2-person dive teams. The two additional personnel were non-divers and came along as observers. The trip to the dive site was uneventful and they arrived in the area around 11:30. At the time of departure, the current weather and diving conditions were excellent, but the weather was forecast to get progressively worse as a storm front was approaching from the east. Due to the impending weather, the dive teams noted that they felt rushed to complete the assigned operation. The boat crew and dive team left the dock knowing that they were slightly ahead of a large storm front. Though given three days to complete this task they knew if they did not complete the operation on March 17th, they would probably miss their window of opportunity to complete the job.

The first two dives were uneventful. The two dive teams were unable to find suitable sites to install sand anchors. This was the preferred method of anchoring the mooring buoys because they could be immediately used after installation. Otherwise, holes would have to be drilled into the base coral and anchoring pins cemented in place. The cement would require approximately a month to cure before the anchors could be used for moorings, thus, delaying the next phase of the restoration project. The desire to find a suitable sand anchor mooring site may have influenced the third dive team to push their dive to the limits of their gas supply and bottom time.

The third dive team was composed of a very experienced diver (DV1(victim)), who had been part of the buoy maintenance team for several years and a second diver (DV2), who had recently completed the NOAA Working Diver training program although he had many years of SCUBA diving experience. DV1 was specifically assigned as DV2's dive buddy because of his many years of diving experience especially with the buoy maintenance team. The third dive team joked about being the "A-team" before their dive.

DV2 wore a 90-cubic foot steel tank with the standard NOAA SCUBA configuration (Oceanic first and second stage regulator, Sea Quest buoyancy compensator device (BCD) with an in-line octopus regulator). DV1 had the same equipment with the exception of the octopus regulator. Instead of the in-line regulator on the BCD, DV1 used a Sherwood model Shadow Plus attached to the Oceanic first stage with a long intermediate hose. The Shadow Plus incorporates an air source bypass tube to which was attached a buoy inflation device. This appeared to be an undocumented modification of the standard NOAA Dive Center (NDC) provided SCUBA equipment. DV1 also used a Diving Unlimited International (DUI) Weight and Trim System™ that was issued from the NDC upon request. While different than the standard diver's weight belt, it is a very simple system and intuitively obvious to use (requiring no special training). None of the diver's tanks had "J" valves (a mechanical reserve device which

closes a spring loaded valve at about 500 psi releasing the remaining gas in a SCUBA tank when the diver turns the valve a quarter turn). All of the divers' regulators had submersible pressure gauges which allow a diver to continuously monitor their breathing gas pressure, measure their gas consumption, and allows them to terminate their dive before they are low on gas. None of the divers were equipped with a diver-carried reserve gas supply or a secondary BCD inflation device.

The third dive team began their dive at 13:33 and did in fact find a suitable site with sufficiently deep sand for installing a sand anchor after checking a couple of unsuitable locations. DV2 inserted an 8-foot long by 5/8-inch diameter copper probe rod three times in separate locations into the sand bottom using an eight-pound sledge hammer. DV1 held the rod to guide it into the sea bottom during the hammering episodes. The rod was then removed and a 24-inch duckbill anchor was inserted into the third probe site with a 30-inch removable driving rod. Once the duckbill was inserted, the drive rod should have detached leaving the duckbill securely in place. The team could not detach the drive rod from the duckbill and had to reinsert the duckbill two additional times. After the attempts at installing the duckbill anchor for a location marker, DV2 signaled that he was low (600 psi) on breathing gas. DV1 checked his pressure gauge and signaled "OK" but never showed the pressure reading of his own gauge to DV2. The amount of work and exertion of DV1 and DV2 was greater than that of the previous two dive teams and would likely require more breathing gas than the previous dives irrespective of the individual's breathing gas consumption differences. DV1 and DV2 collected their tools and clipped them to the bottom of their ascent line for later retrieval and began their ascent. DV2 led the ascent to their 15-foot safety stop with DV1 slightly below (about at DV2's knee) and to the right of DV2. The dive was planned for a 110-foot depth (the actual depth on this dive was 104 feet) with a 15-minute bottom time followed by a 5-minute safety stop at a 15-foot depth and then an ascent to the surface. All dives were conducted using nitrogen/oxygen (NITROX) breathing mixtures containing 68% nitrogen and 32% oxygen. The maximum allowable bottom time for a 110-foot dive is 30 minutes using a 32% NITROX gas mixture (the maximum allowable time is 20 minutes if breathing air). Upon reaching their 15-foot safety stop, DV1 went straight to the reserve gas cylinder. The cylinder valve was left secured until needed to ensure the regulator did not free-flow due to wave action while the divers are on the bottom and vent out all of the emergency gas before it might be needed. DV1 reached over DV2's shoulder, grabbed the second-stage regulator and attempted to breathe from it. Since the valve was not yet open, no breathing gas was delivered to DV1. After opening the valve, DV2 turned to face DV1 and noticed that he was unresponsive and sinking. DV2 grabbed DV1 by his BCD. They were negatively buoyant and sinking; DV2 began to run out of breathing gas and released his own weight belt in an attempt to quickly regain buoyancy control, but was unsuccessful. DV2 quickly realized that he did not have enough breathing gas to affect rescue before both divers sank to the bottom and, therefore, made the decision to release DV1 and immediately surfaced to summon help.

The SBSD immediately donned his equipment and entered the water. The SBSD located DV1 lying on the bottom of the sea floor unresponsive. Although not completely

sure, the SBSD thinks he noticed that the regulator was not in DV1's mouth. At topside, a call had already been made to the USCG for immediate medical assistance. The SBSD released DV1's twenty-four pounds of weights and brought the stricken diver to the surface arriving at 13:54. The total time from the call for help until DV1 was on the surface was approximately three minutes. The victim was quickly recovered on the starboard side aft quarter of the diving vessel, by lifting DV1 approximately two and a half feet from the water onto the deck. Oxygen and CPR were immediately administered to the victim. Once all crew members were back on board the boat, they departed the incident scene at 14:08. Initially the dive team thought there would be a helicopter transfer directly from the MV Peter Gladding so they started heading back to Key West to make the helicopter trip shorter. They were informed after 15 minutes of travel back to Key West that the helicopter would not transfer directly from the vessel, only from Fort Jefferson. The vessel was 18-20 nm away from Fort Jefferson and the sea conditions were 3-5 foot seas. They diverted to Fort Jefferson arriving at the dock of the Dry Tortugas National Park at 14:42. They were met by the National Park Service Rangers who took over emergency medical treatment including the use of an automated external defibrillator (AED) on the victim. They quickly transferred DV1 to the medical evacuation helicopter (Trauma Star 1) which had arrived at that time and departed for Lower Keys Medical Center at 15:32 arriving at 16:15. DV1 was pronounced dead by the attending emergency room physician at 16:22.

INCIDENT TIME LINE

07:00: NOAA vessel GLADDING commences underway preparations.
08:00: All gear loaded aboard.
08:58: NOAA vessel GLADDING gets underway.
11:30: NOAA vessel GLADDING arrives at first dive site.
11:57: First dive commences.
12:23: First dive completed.
12:50: Second dive commences.
13:10: Second dive completed.
13:33: Third dive commences.
13:51: DV2 reaches surface and gives distress signal.
13:54: Initial call made to United States Coast Guard.
13:54: Standby diver surfaces with victim.
13:58: Victim on board NOAA vessel GLADDING. CPR and O2 administered.
14:22: Monroe County Sheriff's Office (MCSO) engaged to initiate medical evacuation.
14:42: NOAA vessel GLADDING moored at Dry Tortugas National Park.
15:32: DV1 transferred to the medical evacuation helicopter (Trauma Star 1).
16:15: Trauma Star arrives at Lower Keys Medical Center.
16:22: DV1 pronounced dead by attending emergency department physician.

INCIDENT CLASSIFICATION

In accordance with the NOAA Incident Investigation Procedures (NIIP) Manual, this incident is classified as a Class “A” mishap due to the incident resulting in a fatality.

PRE-MISSION CONDITIONS

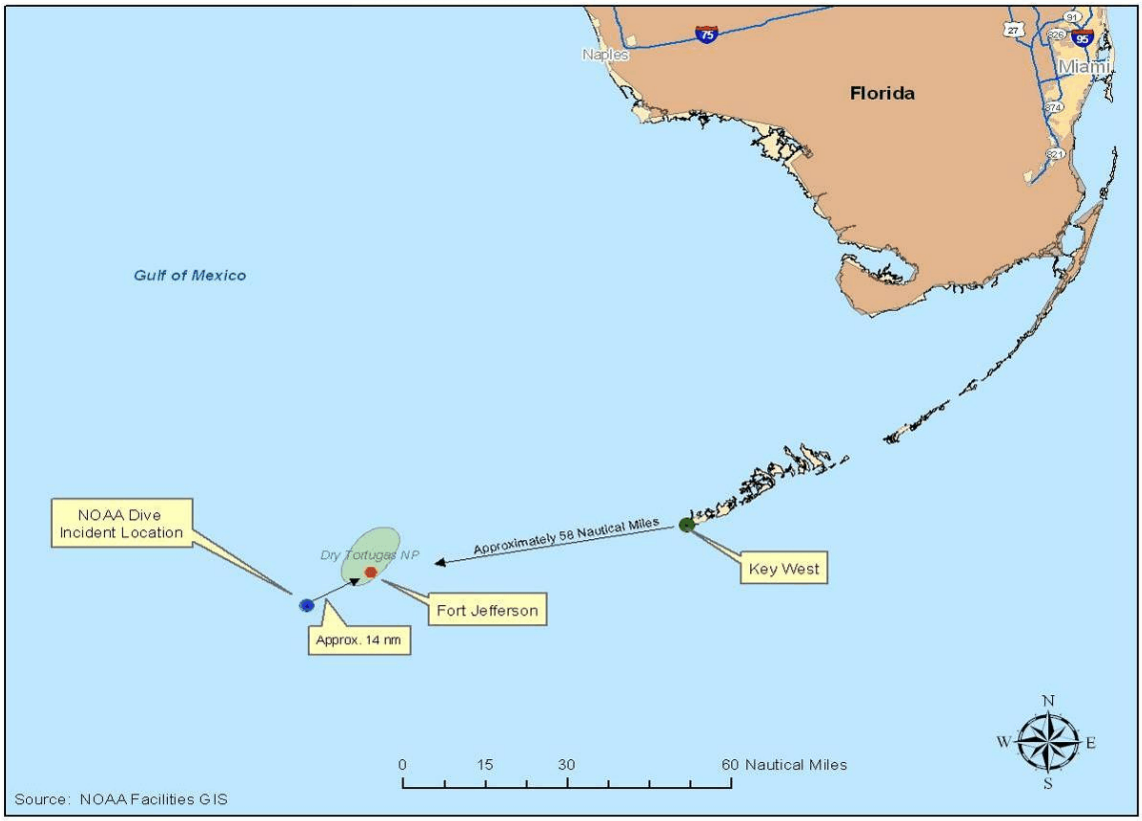
a. Vessel Information

Name: MV Peter Gladding
Year: 2006
Property ID: R5701
Make: Teknicraft
Model: LE Catamaran
Built in: New Zealand
Length: 53 feet
Beam: 20 feet 6 inches
Hull Type: Twin Hull Design
Hull Number: TD 17-18AA
Propulsion: Twin Engine Jet-drive

b. Crew Composition

The crew consisted of eight members:
Vessel Captain/ Diver (FFWCC)
Unit Dive Supervisor/ Dive master/ Diver (NOAA)
Diver 2 (FFWCC)
Safety Diver (FSDEP)
Diver (FSDEP)
Diver 1 (FSDEP)
Crew Member (NOAA)
Crew member (FFWCC)

c. Dive Location



d. Meteorological Information

The following weather information was provided by the NWS-WFO Key West (coastal waters forecast) via a telephone conference brief on the morning of the mishap:

Winds: 10-15 knots
Seas: 1-2 feet
Visibility: 100+ feet
Skies: Sunny

CONCLUSIONS

The victim depleted his breathing supply at depth, either while on the bottom or during his ascent to the 15-foot safety stop. This subsequently led to the victim becoming unconscious and drowning prior to reaching the pre-staged breathing supply available at the safety stop. The victim did not struggle, fight, or seem in duress, leading one to conclude that he went unconscious before the urge to breathe became overwhelming as would be expected in a drowning incident. The victim did not share breathing supply pressure readings with his buddy, or otherwise seek assistance via buddy-breathing during ascent.

It is widely recognized that the number one factor in diver injury and fatality is diver error and poor judgment. Arguably then, the single greatest contributing factor to this fatality was the victim's decision to push the limits of his breathing supply. As discussed in the report, a number of factors, cumulatively or alone, could have contributed to DV1 [the victim] ignoring required diving safety standards (minimum 500 psi, strict adherence to buddy system parameters, failure to monitor air supply) associated with proper termination of this dive and appropriate and safe ascent. Regardless, we can conclude the victim made a series of poor decisions which ultimately led to his demise. Other factors, however, can also be surmised as possibly contributing to the incident.

In the workplace, responsibility for employee safety ultimately rests with the employer. It is the employer's responsibility to provide safety checks and safety systems. These checks are designed to constrain employee error and lack of judgment. In sum, the employer is responsible for providing all employees with the necessary equipment and parameters with which to undertake their work. In this instance, failure to understand and adhere to applicable occupational standards for diving resulted in the failure to provide a reserve breathing supply to this diver, as well as a tender and stage that might have expedited or promoted more immediate life saving attempts. This organizational failure can be considered a contributing factor to this fatality.

Prior to this incident the NDP had an impressive safety record. This does not mean, however, that there is not room for improvement, or that there are not deficiencies in the program's ability to manage diver safety, particularly in light of recent revelations that there have been other "near miss incidents" related to NOAA divers depleting their breathing supply at depth. While organizationally it is difficult to institute policy to control the thought processes and actions of individuals, certain policies and procedures designed to mitigate human error and protect employee's from themselves must be instituted in the work-setting. While DV1 was responsible for factors in his control-monitoring his breathing supply, communicating with his dive buddy - it is the Dive Program's responsibility to provide him all necessary tools and comply with the legal standards designed to protect him while he is at work.

Ultimately, it is management's responsibility to develop, maintain, train and enforce safety standards, policies and procedures. It is management that dictates and ensures

the safety culture of an organization. Accordingly, management must work to ensure employees are protected from work place hazards, from themselves, and from potentially unsafe actions of their co-workers. Toward this end, one element of a safety-conscious organization is the availability of clear and readily identifiable and enforceable policies, procedures and standards designed to provide safeguards to prevent independent employee judgment from overriding necessary safety parameters.

This investigation reveals that additional steps should be taken by NOAA to strengthen the safety culture within the NOAA Dive Program and minimize the danger that any diver places himself in during NOAA missions. Most of these steps consist of organizing, structuring and clearly defining applicable legal standards for NOAA Dive Program employees and end users. These steps, if implemented prior to this incident, may not have prevented the dive fatality; however, failure to take these steps may perpetuate an environment that elevates the risk of recurrence of such an incident in the future. A well-structured safety-based program, with clear standards applicable to specific dive operations and situations, clearly defined roles and responsibilities, and clear and enforceable consequences of failure to comply with such standards and safe dive operations is paramount in minimizing on-the-job injury and loss of life. Specific issues that require NOAA's action include the following:

Scientific Dive Standards. NOAA should more clearly delineate what constitutes scientific diving in order to clearly differentiate such dives from "working dives" that are subject to the Subpart T standards under 29 CFR § 1910. Further, NOAA must develop and publish a NOAA Diving Safety Manual that establishes clear standards and clearly defines roles and responsibilities to maintain a safe scientific dive program.

Reserve Gas Supply for Scientific Dive Operations. While Subpart T imposes requirements for reserve gas supply for both mixed gas and compressed air dives for commercial dive operations, NOAA's dive program does not specify conditions or criteria for required use of reserve gas supply for scientific dive operations. While the incident dive was not apparently conducted under NOAA's scientific dive exemption, the incident did highlight the absence of clear reserve gas supply standards for scientific dives.

Clarification of Applicability of OSHA Subpart T Standards to Non-Scientific Dives. As stated previously, there appears to be misunderstanding and misinterpretation of the applicability of OSHA Subpart T standards to non-scientific dives conducted beyond the 3nm OSHA compliance jurisdiction. Since analysis coordinated through NOAA and OSHA's legal counsel have clarified that OSHA standards apply to all NOAA "working" (i.e., non-scientific) dives, irrespective of where such dives are conducted, this clarification must be shared with the diving program community. In addition, the applicable standards (mixed-gas versus compressed air) for such working dives must be clearly articulated and enforced to ensure safety is not compromised.

Clarification of Consequences of Failure to Adhere to Standards and Safety Requirements. A well-designed and easily understood safety program will include

safeguards to identify and preclude from participating in future dive operations individuals who do not comply with NOAA diving standards or who engage in unsafe dive practices, or who do not present themselves as being fit at the time of the dive. Such individuals potentially pose a risk to themselves and/or others, and a risk to the overall safety culture that is successful to an effective diving program. At the time of this fatality, the NOAA Dive Program lacked the understanding, structure and definition to provide necessary safeguards. Had they been in place, the victim might have been pre-empted from this dive, or might have already faced consequences that would have incentivized adhering to safe dive procedures. This would serve to send a powerful message to the individuals that depart from policy and procedures that their actions won't be taken lightly. Offenders should be permanently removed from diving duty.

NITROX as a Breathing Media. While the use of NITROX as a breathing media has proven to be safer than compressed air in certain applications due to the increased partial pressure of oxygen and decreased partial pressure of nitrogen; the applicable regulations classify this as a mixed gas dive. Mixed gas diving in accordance with the regulations requires much more infrastructure and support than that which is currently available to the NDP. It is very clear that the applicable federal regulations have not kept pace with developments in diving technology and available equipment. Nevertheless, the regulations must be followed. Because NOAA has had a safe and successful history of diving NITROX and has made a significant investment in NITROX systems, it would be in the organizations best interest to lobby for changes to existing regulations to bring them up to date. Alternatively, the Agency should develop their own approved regulations and requirements for NITROX diving. Until the NDP can comply with the requirement of the current mixed gas diving regulations, lobby for a change to the regulations, or develop their own requirements, they should cease NITROX diving in SCUBA gear as they currently stand in direct violation of federal law. This distinction should be made widely known in the NOAA Dive Program.

CORRECTIVE RECOMMENDATIONS

NOAA Dive Program should:

Immediately:

1. Cease use of NITROX as a breathing media until such a time that NDC can develop policy regulating mixed gas diving or lobby for change to the current applicable regulations.

Issue clear guidance to all NOAA divers and DM's regarding:

2. Applicable diving regulations and dive classification distinctions
3. Dive equipment authorized for use and its proper configuration.
4. The requirement to conduct pre-dive briefings and equipment checks.
5. The requirement to surface with a minimum of 500 psi in SCUBA cylinders.
6. Undertake an analysis of all current NOAA gear for conformity with applicable OSHA regulations and correct gear deficiencies.
7. Ensure NOAA dive certification includes mandatory training in NOAA diving regulations, standards and policies; diving procedures; and diving equipment.
8. Ensure the availability of a standby diver when dives are greater than a predetermined limit (e.g., 100 feet).
9. Remind divers of their responsibility to refuse to dive, without fear of any reprisal, if conditions are unsafe or unfavorable, if they feel they are not physically or mentally fit to dive, or do not have adequate training or experience to perform the assigned tasks.
10. Remind divers of their responsibility to notify the diving supervisor of any changes in their fitness to dive (i.e., changes in medications, minor physical injuries, etc.)
11. Review the established protocol of accepting other organization's dive training certifications or equivalent experience as an acceptable means of approving non-NOAA personnel to dive under the NOAA Dive Program.
12. Require each dive unit to develop the use of written operating procedures for all aspects of diving operations (e.g., running compressors to fill cylinders, pre-dive briefs).
13. Develop expanded and clear dive regulations and policies to include more guidance associated with the day-to-day management of dive operations, together with a clearer articulation of decision points relative to roles and responsibilities.
14. Establish policy and procedures adopting a NOAA Dive Control Safety Board and set clear standards defining scientific versus working dives- consistent with the OSHA scientific dive exemption.

Within the next year:

15. Consider more emphasis on training divers to calculate their gas consumption under various diving conditions and requiring divers to carry an independent reserve breathing gas supply for deeper dives or when performing arduous tasks.
16. Ensure UDS approves divers to perform advanced work-related skills in shallow water (<60 feet) before being permitted to perform these skills in deeper water.
17. Consider instituting, beyond the required diving physicals, a means of assessing the physical fitness level of all divers on an annual basis (e.g., U.S. Navy Physical Readiness Testing Standards).
18. Consider requiring a formal written dive-plan to be reviewed and approved by the UDS or their designee for all open-water diving operations.
19. Consider requiring a pre-dive checklist for all open-water dive operations.
20. Consider requiring a safety stand down day each year to review NOAA diving regulations, standards and policies; diving procedures; and diving equipment and conduct (and document) in-water emergency drills.
21. Consider establishing a dive unit inspection process in addition to the annual self survey which would include inspection by an outside entity (NDC representative) that could observe the dive team while operating, conduct drills, and review the requirements contained in the self survey.
22. Consider a means to allow the dive supervisor to communicate with divers diving at depths exceeding a predetermined limit (e.g., 100 feet).
23. Research the possibility of purchasing an in-line warning system that triggers an audible signal and strobe light when the pressure in the gas cylinders reaches a pre-set low capacity. This could warn divers the gas consumption has reached a point where the diver needs to surface in order to maintain a safe ascent without exceeding the minimum air pressure requirement and to avoid drowning.
24. Consider reinforcement of established policies and procedures to all diving units with emphasis on dive planning and following the dive plan, education, and most importantly eliminating the general complacent aura of this is a “routine dive.”
25. Examine the feasibility of and need for drug testing/urinalysis in the NOAA Dive Program.
26. For NOAA Command Element positions where the Officer in Charge will have divers under his /her control and where the respective Officer in Charge has not previously qualified as a NOAA diver; NOAA should create and implement an executive level dive familiarization course. This course should provide the attendee with a brief overview of NOAA dive policy and procedures and afford the opportunity for the student to observe a diving evolution or evolutions to see what “normal” dive operations should look like.

FKNMS should:

Immediately:

27. Ensure that dive worn equipment is in adherence with current NOAA requirements.
28. Require the use of an established checklist for all dive operations. To include a complete dive brief prior to deploying on a mission.
29. Require the dive supervisor to perform a hands-on check of each diver before deploying and ensure the diver understands safety and mission requirements.
30. Ensure persons serving in a capacity of dive support are trained for the scope of responsibility and are appropriately designated.

Within the next year:

31. Develop written procedures for mixing NITROX and filling SCUBA cylinders. These procedures shall be posted at the dive locker.
32. Perform an assessment of divers breathing rate to better plan gas consumption rates for divers.

NOAA Small Boats Program should within the next year:

33. Consider requiring an automated external defibrillator to be included as part of the NOAA Small Boats Program emergency medical equipment on designated small boats. Ensure equipment is rated for a salt water environment.