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Contamination Risk for Underwater Divers (CRUD) Workshop Proceedings Summary Report

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ADMINISTRATIVE INFORMATION

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Editor: MRM

EXECUTIVE SUMMARY

The Contamination Risk for Underwater Divers (CRUD) Workshop was convened by the Office of Naval Research (ONR) and Naval Information Warfare Center Pacific (NIWC Pacific) to facilitate an open forum and dialogue between contaminated water diving (CWD) community stakeholders, for purposes of discussing diving concerns related to aquatic environmental contamination, which can be characterized within a risk framework. The workshop was focused on the identification and evaluation of critical aspects of chemical and biological hazards at dive sites that may drive potential risk associated with diving in contaminated water. Particular emphasis was placed on the sharing of known impacts, potential challenges and solutions, and experiences, including lessons learned, that might lead to synergies amongst CWD stakeholders going forward. The workshop initially focused on developing a problem statement from a high-level perspective that would serve as a starting point from which discussion by participants would commence in order to identify and incorporate important aspects that were necessary for consensus-building.

As part of this initial problem definition effort, high level presentations were provided. These included a services perspective, a summary of the state of the science, and an overview of conventional risk-based approaches that either had been used previously or could potentially be used as a starting point for understanding and assessing CWD in a risk-based framework. These presentations and related discussions were followed throughout the remainder of the workshop by thoughts, experiences, and challenges related to CWD risk characterization, that were considered important to each of the stakeholder organizations.

This set the stage and provided a backdrop for building a consensus regarding the inherent complexities of diving in contaminated water sites; what is known about CWD-related issues, in addition to what is not known, or gaps that exist in our understanding of those issues; what data might already be available, and correspondingly, what data gaps exist; followed ultimately by discussions regarding how to go about developing solutions and approaches in response to the challenges identified.

The following proceedings capture the details of topics and related free-flowing discussions as they occurred in real time, and in an appropriate level of detail, with the goal of providing the reader with a sense of current issues that are germane to CWD risk. Appendix A contains presentation materials that were provided to the group, which are included as supporting documentation for those discussion topics.

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1. BACKGROUND

Water pollution is a global issue. With relatively few exceptions, most water bodies contain some level of contaminant loading burden (biologic and/or chemical). While forward operation sites located in Latin America, Asia, and Africa pose the greatest risk of exposure (in some cases 70% of their water resources receiving an impaired/poor condition rating) [1], the probability of exposure to contaminants of concern within developed countries is still high [2, 3]. According to the 2017 US Environmental Protection Agency (EPA) Water Quality Inventory Report to Congress [2], at least 43% of US water resources are listed as impaired or unable to support at least one of their designated uses. This number rises to an average of 76% when comparing the total number of sites monitored to total number of sites listed. In particular, and of specific relevance to Navy divers, some of the highest numbers of impaired sites listed (coastal water estuaries, embayment, great lakes and shore lines) are associated with types of waterbodies our troops would frequent for routine operations. As a result, the potential exposure to contaminated waters during both day-to-day operations and special mission critical operations pose a serious problem for divers.

In addition, many military operations rely on quality water. As such, the Department of Defense (DoD) views water pollution as a potential health and safety risk for our armed forces [4], making it imperative to anticipate, understand, evaluate, and address the potential threat. As a result, proper preparation, identification of potential contaminants of concern, and monitoring of contaminated water remain issues of concern for the Navy, Marines and forwardly deployed organizations needing safe water resources.

While there have been funded efforts, which have focused on the improvement of personal protective equipment (PPE) and the development of more real-time *in situ* sensors for detecting contaminants of concern, most Federal and DoD funding has focused on emergency response planning and water purification. This is due, in part, to current limiting aspects of the available technology (e.g., reagent-dependent, target-specific, and time consuming). Additionally, these methods lack a quantitative approach and capacity to sort through a complex, heterogeneous environment. While the ability to evaluate and address the potential threat, via improvements to sensors and PPE, continues to improve, our ability to anticipate and understand the threat remains a critical issue.

Historically, there have been attempts within the dive community and at an organizational level to aid dive lockers in better defining potential threats. However, most of those endeavors focused on site-specific or mission-specific evaluations and/or applications [5, 6, 7]. For example, many organizations within the DoD and outside have held various forms of workshops targeting contaminated water diving applications (e.g., Coastal Trident Contaminated Water Diving Exercise 2019) [8, 9]. These workshops help the dive community walk through how they might respond to specific contaminated water dive scenarios and/or utilize PPE and sensor resources. Yet without better guidance for how to identify potential exposure risks, it is difficult to anticipate resource needs. While some risk evaluation tools/reports have been developed, these resources are limited in scope (e.g., NIWC Pacific Contaminated Water Diving Information Development Report), site or scenario specific (e.g., Jebal Ali and Djibouti site health risk assessment), developed for more broad fresh water and/or swimming application (e.g., CDC Surveillance Reports for Recreational Water-associated Disease & Outbreaks), and/or organizationally encapsulated (e.g., not generally known about and/or available outside a specific organization, such as DTRA repository) [5, 10].

In light of this, the Office of Naval Research (ONR) Undersea Medicine Program Office, in consultation with the larger dive community, sought to gather informed representatives to better understand concerns and issues surrounding diving in contaminated waters from a global perspective.

This included government agencies, private sector, and academic representatives who are charged with developing, responding with, and/or deploying various resources when faced with mission scenarios involving contaminated waters. Invited attendees were drawn from individuals/organizations charged with mitigating potential adverse health effects related to diving in contaminated waters and/or had some form of expertise related to understanding risks associated with contaminated water exposure. The primary goal of this meeting was to gather information and ensure an intimate setting for open dialogue. Individuals were invited based on their prior involvement, interest, and/or expertise in contamination risks associated with underwater diving. The workshop sought to bring together individuals who could help answer such questions as: What types of scenarios should be considered? What types of problem(s)/contaminants have they observed? Of those, are there known threats to human health? What is the magnitude and nature of the risk? This group, collectively referred to herein, make up the Contamination Risk for Underwater Divers (CRUD) stakeholders.

This document provides a summary of this two-day event.

1.1 GOALS

1. Better understand past, present, and future initiatives related to environmental water quality contaminants, safe exposure limits, and environmental scenarios.
2. Develop solutions for addressing Contaminated Water Diving issues that are scientifically based, realistically achievable, and designed to protect diving personnel.

1.2 OBJECTIVES

1. Define global risk characteristics
2. Obtain consensus
3. Develop solutions or requirements
4. Define mitigation path for potential adverse health effects related to diving in contaminated waters
5. Identify key near-term and long-term capability gaps
6. Foster communication between stakeholders

Table 1. List of Workshop Attendees.

Group	Name
Office of Naval Research (ONR)	Dr. Sandra Chapman
Naval Information Warfare Center Pacific (NIWC Pacific)	Dr. Kara Sorensen
Naval Information Warfare Center Pacific (NIWC Pacific)	Dr. Rob George
Naval Information Warfare Center Pacific (NIWC Pacific)	Dr. Patrick Sims
Naval Information Warfare Center Pacific (NIWC Pacific)	Ms. Cassandra Sosa
Naval Sea Systems Command (NAVSEA) OOC - Supervisor of Diving	CAPT Thomas Murphy
Commander Naval Sea Systems Command (COMNAVSEASYSCOM) DC	Dr. David Southerland
Naval Sea Systems Command (NAVSEA)	NDCM John Hopkins
Divers Alert Network (DAN)	Dr. James Chimiak
Divers Alert Network (DAN)	Dr. Frauke Tillmans
United States Environmental Protection Agency (EPA)	Mr. Sean Sheldrake
United States Environmental Protection Agency (EPA)	Mr. Scott Grossman
National Oceanic and Atmospheric Administration (NOAA)	CDR Eric Johnson
Navy Expeditionary Combat Command (NECC) Force Master Diver/N7C SEA	NDCM Michael
NAVSEA Executive Fellow/Navy Experimental Diving Unit	Mr. Vincent Ferris
United States Coast Guard (USCG)	CWO Joe Erwin
Navy Marine Corps Public Health Center (NMCPHC) Environmental Program	Dr. Paul Gillooly
Navy Marine Corps Public Health Center (NMCPHC) Environmental Program	Dr. Alan Philippi
Office of the Under Secretary of Defense for Research & Engineering Support	Ms. Jennifer Coughlin
Smithsonian Scientific Diving Program	Ms. Laurie Penland
National Institutes of Health (NIH) / National Institute of Environmental Health Sciences (NIEHS)	Dr. Christopher Weis
NOAA National Ocean Service (NOS) - Unit Dive Supervisor	LTJG Josh Fredrick
Naval Facilities Engineering & Expeditionary Warfare Center (NAVFAC EXWC)	EOCS James McVicar
Naval Facilities Engineering & Expeditionary Warfare Center (NAVFAC EXWC)	LT Reece Comer
Naval Medical Research Center (NMRC)	Dr. Aaron Hall
Naval Medical Research Center (NMRC)	LT Geoffrey Ciarlone
US Army Engineer School; 92nd Engineer Battalion	CPT Hackett Landefeld
ROH Inc.	Mr. Phillip Colon
Naval Sea Systems Command (NAVSEA) OOC	CAPT David Regis
Royal Australian Navy, Medical Officer	CDR Douglas Falconer
Centers for Disease Control and Prevention (CDC)	Ms. Michele Hlavsa
Centers for Disease Control and Prevention (CDC)	Dr. Art Chang
Centers for Disease Control and Prevention (CDC)	Dr. John Sarisky
Defense Advanced Research Projects Agency (DARPA)	Dr. Jacob Goodwin
Duke University	Dr. Rachel Lance
Defense Threat Reduction Agency (DTRA) Research and Development (R&D)	Dr. Don Cronce

Contact information for those individuals listed above was provided as part of the workshop program and has also been uploaded to the CRUD stakeholder working group share site.

2. INTRODUCTION

The primary goal of this two-day event was to attain a more global understanding of the breadth of Contaminated Risk for Underwater Diving (CRUD) issues. This included defining similarities in types of scenarios/experiences and better understanding the synergy of the issue, regardless of applied scenario, and/or what would be considered a stakeholder-specific area.

While identification of future research and data gaps needs were discussed, ultimately the purpose of the workshop was not to be sensor or technology driven. Instead, discussions were meant to focus on defining the overall risk associated with contaminated water diving.

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3. DAY 1 OF WORKSHOP

3.1 INTRODUCTION TO TOPIC; GLOBAL PROBLEM FROM DOD PERSPECTIVE AND DEFINING WORKSHOP OBJECTIVES

The first day of the workshop (morning session) was designed to set the stage for a contaminated water risk-based discussion. The workshop host provided an overview of contaminated water issues from a DoD perspective, as well as current state of understanding, and introduced the main goals of the workshop. All presentations were unclassified. All publicly-releasable presentations have been uploaded to the CRUD Stakeholder working group share site (https://wss.apan.org/navy/CRUD/default.aspx). A brief summary of each presentation and subsequent discussion is provided below. The CRUD workshop meeting agenda can also be found on the CRUD Stakeholder working group share site. A summary of presentations is provided in the order they were given. Where possible, subheadings have been added to delineate the different topic areas discussed.

3.1.1 NAVSEA 00C3 Contaminated Water Diving

Presenter: CAPT Thomas Murphy, US Navy Supervisor of Diving

Summary:

CAPT Murphy provided a brief covering the following areas: the organization of the Naval Sea Systems Command (NAVSEA) Supervisor of Salvage and Diving (SUPSALV) and their role as it relates to diving; the *Guidance for Diving in Contaminated Water* policy document; scenarios that required diving in contaminated water; and US Navy Contaminated Water Diving (CWD) capability gaps.

When discussing the SUPSALV organization, CAPT Murphy highlighted the main foci concerning diving. These foci are the *US Navy Diving Manual*, diving policy, procurement of diving equipment, equipment testing and diving accident investigation through the Navy Experimental Dive Unit (NEDU), diver health and safety, and biomedical research involving disabled submarines and diving through the US Navy Deep Submergence Biomedical Development Program (DSBD).

Following this, CAPT Murphy provided an overview of the revised *Guidance for Diving in Contaminated Water* technical manual, which provides direction for US Navy activities conducting contaminated water diving operations for the purpose of providing maximum protection consistent with the contamination threat. He highlighted what the technical manual provides:

- Definitions of contaminants and hazards
- Equipment considerations
- Pre-dive planning considerations
- Decontamination procedures and Standard Operating Procedures
- Information sources and links
- NAVSEA decontamination equipment inventory

He also highlighted what the technical manual does not provide, including:

- Identification of specific biological contaminants of concern
- Incorporation of specific contaminants of concern into established contaminated water categories, i.e.
    - CAT 4: Baseline contaminated (low risk of injury)
    - CAT 3: Moderately contaminated (some risk of injury, especially if ingested)
    - CAT 2: Heavily contaminated (high risk of injury)
    - CAT 1: Grossly contaminated (extreme risk of injury or even death)
- A standardized risk management decision making aid based on quantifiable metrics

When discussing the current lack of incorporation of specific contaminants and their levels into specific contaminated water categories, CAPT Murphy emphasized the importance of linking policy and direction to these types of guidance documents. This mitigates cases where the user may decide on lower levels of protection, and therefore assumes risk without being fully aware of the risk and potential impacts.

Further, he emphasized the importance of translating the information to be palatable to the dive user side, so they can incorporate it into their operational risk matrix and understand the risk or hazard.

Following this, CAPT Murphy described three examples of diving operations involving contaminated water:

1. Port contamination in Dubai, UAE
2. Port contamination in Djibouti
3. Ship salvage contamination with USS McCain

Port contamination in Dubai, UAE is co-located with an aluminum plant and sugar refinery. In this example, the water conditions fluctuated on a monthly timeframe in the inner harbor where the water would turn a purple hue, emit a strong odor, and corrode equipment. In addition to the contamination issue, he spoke of the operational considerations of diving in water temperatures that range from 70ºF in winter to 95ºF in the summer, and how that can impact the implementation of protective measures. For this particular event, the contamination was readily evident using sensory observation. The key points highlighted in this example were that the responsiveness of testing takes time. On average, it takes between eight months to a year to get appropriate personnel to conduct testing. However, the environment changes over time (i.e., purple water reverted back to clear and back to purple), and knowledge of these types of events needs to be transferred as teams rotate in and out of the location for continuity. Additionally, CAPT Murphy referenced how continual monitoring and reporting may be helpful in capturing temporal fluctuations within the water column.

Port contamination in Djibouti is impacted by runoff from a livestock holding area and coal staging area at the port, leading to both biological and chemical contamination concerns. One of the impacts highlighted was how an infected wound has the potential to impact a small dive team's ability to conduct a mission. Again, CAPT Murphy emphasized the need to incorporate water temperature into the risk matrix as to what protective equipment will be used and the need for teams

to collect, maintain, and share information with incoming teams. In this way, the incoming teams can use technology effectively, use the appropriate protective measures, and are outfitted with the right PPE.

Ship Salvage Operations with USS McCain was a dive response to the USS McCain explosion. In this example, CAPT Murphy highlighted some of the hazards that a diver faces in this type of environment, such as: limited space, sharp metal, warm waters, and presence of lube oil, fuel oil, and human remains. He emphasized that operational requirements are not always conducive for the use of some PPE, and that teams must make best assessments in certain scenarios. During this operation, the dive teams had medical support personnel and decontamination stations available.

CAPT Murphy described US Navy Contaminated Water Diving capability gaps. His specific list was as follows:

- No definitive list of contaminants and accompanying go/no go criteria
- No CAT 1 diving capability, i.e., lack of approved equipment for diving under grossly contaminated conditions
- No ability to continuously maintain diver comfort through the entire range of diving capability temperatures in a contaminated environment
- No standardized/responsive test program

The first concluding point focused on the standardized response plan and asked rhetorically how we can work towards a standard medical response plan in order to develop a plan of action and milestones, and broaden support to the Fleet. He also highlighted some of the current work towards closing the CAT 1 diving capability gaps, such as: Kirby Morgan KM 97 dive helmet, and closing the gap of maintaining diver comfort in thermally extreme contaminated environments (i.e., a chiller/heater system).

The last point was the need to begin with policy and risk, and then follow-up with equipment. The reason: policy drives the use of more cumbersome and harder to use equipment.

Discussion:

Following the presentation there was discussion that mainly focused on Dubai and Djibouti events.

Dr. Chimiak asked if any analysis had been done at the ports, and Dr. Gillooly stated that they have a project investigating this and met with the Port Authority in Dubai, who thought the purple color arose from the use of a cellulose-based dust suppressant. Dr. Gillooly also stated that they requested a report, which was not provided, and stated that even at large, commercial ports the regulatory structure is not necessarily present. Dr. Gillooly further emphasized that the Port Authority does have a list of chemicals and biologicals that they claim to sample, but attaining that data overseas is often challenging. CAPT Murphy echoed this sentiment and stated that they have updated the contaminated water diving manual about where to obtain information on sampling programs within the United States.

In regards to sampling, CAPT Murphy stated any sampling process would need to be standardized to account for time-dependent fluctuations in water quality, and that currently the teams do not have

sampling kits available. He stated that the larger issue is how to test, monitor, and maintain the data, and provide it to the teams that operate in that area. On this point, (an unknown individual) stated that the available data is often old information.

Mr. Sheldrake stated that the questions regarding how to adequately sample often reach back to the following questions: What is a particular agency concerned about? What is considered acceptable or unacceptable? He provided an example that agencies with divers on short rotations may be concerned with acute exposure of contaminants, while agencies such as the Environmental Protection Agency with career divers may be more concerned with impacts of long-term exposures. He stated that the answers to these questions would aid in designing the surveillance program. He stated that, in terms of chronic exposure, he would expect a number of contaminants in a harbor, either chemical or biological with non-cancer or cancer-end points, that would be of concern to EPA divers. Building on this, he emphasized that building a sampling system around this would be expensive, not real-time and that certain chemicals such as dioxins and furans could be below quantitation limit and still pose an excess cancer risk. In regards to the frequency of sampling, he stated that one may want to examine the data with the understanding that contaminants within water column may fluctuate with time, while those in the sediment should remain fairly static.

3.1.2 Contamination Risks Associated with Diving: State of Science

Presenter: Rob George, PhD, NIWC Pacific (on behalf of Dr. Kara Sorensen)

Summary:

Dr. George presented an overview of the state of science regarding contamination risks associated with diving. He stated that NIWC Pacific has been working with NAVSEA on this issue since the mid-2000s. He indicated that water pollution is a global issue and stated that most waterbodies have some level of contamination. In reference to the presentation, he stated that 70% of water resources in Latin America, Asia, and Africa are impaired, and that the probability of exposure to some form of a contaminant of concern in developed countries is still high in that a sizeable percentage of US water resources are impaired. In addition, he highlighted that contamination issues arise from both chemicals and biologicals. From DoD context, he stated that health risk is mixed with safety risk from a diving perspective, such that other dive risks may dictate the level of dress rather than contamination risks.

Following this, Dr. George provided what he called the “Response Paradigm,” which is a circular process of anticipating, understanding, evaluating, and addressing risk. He stated that NIWC Pacific had developed an information development report that focused on anticipating and understanding risk, but primarily for a site-specific, narrowly focused scenario, and which also generated a short list of chemical and biological contaminants.

Next, he provided an example of a pre-dive assessment and emphasized that one needs to assess available information and attempt to find what contaminants may be present, at what levels, and whether they will pose an exposure risk to the diver. Following this, he reiterated that the available information to do this is scarce but that decisions must be made anyway. He stated that a primary driver to this lack of information is that sampling and analysis of the environment takes significant resources (time and money). Dr. George stated that this is the current challenge we face.

Following this, Dr. George stated that efforts have been made to detect the chemicals from a short list of chemicals of concern and that investment in equipment has been made to protect from these

contaminants. He provided a quick snapshot of commercial detection capabilities for contaminants as well as dress required for different levels of contamination.

He then stated that what is missing is the front end of the "Response Paradigm," (i.e., anticipating and understanding. He asked, "How do we anticipate what we need to look for?" To get at that question, he suggested that one may try to anticipate potential sources of contaminants and the types of contaminants that may arise from those sources. In terms of understanding, he stated that we need to understand what impact it might have during a dive scenario and to be able to down-select to a list of contaminants of concern at a given site.

He then provided an approach to develop guidance for addressing data gaps that impact how to broadly evaluate contaminated water diving site characteristics and the potential risk to divers. The approach was the following:

- Consider legacy pollutant versus current and future site conditions
- Understand how to address site-specific or emergent contaminants of concern
- Enable dive scenarios to be defined by site-specific characteristics
- Provide a platform, e.g., a workshop where key stakeholders can collaborate and communicate
- Define data gaps and a risk characterization framework
- Build on prior workshops, guidance documents, and other publications

Dr. George provided a summary of how a framework may be applied that examines contaminant characteristics, site-specific characteristics, environmental factors, and mission-specific characteristics in order to characterize risk. This then informs the contaminant detection and personalized protective equipment considerations.

Concluding, he emphasized that the workshop should focus on how to develop that understanding, anticipate what one could expect, identify potential solutions, and identify data gaps.

Discussion:

Following this presentation, there was a short discussion on the cost of quantifying samples.

Dr. Hall asked for approximate prices of point-of-need technologies to assess for certain contaminants, and a suitable price point. He provided an example of an instrument that costs $50K, or a disposable test that costs $100. Dr. George stated that the price point ranges on what you are looking to identify and that it would be up to the agency.

Mr. Sheldrake added that field screening can be done for pertinent contaminants at higher levels that are 1 in 1,000 or 10,000 excess cancer risk, versus managing 1 in 1,000,000 excess cancer risk. In addition, he stated that high volume sampling is required for some contaminants along with proper preservation. He provided an estimate of $10 for metals and $2K–$3K for dioxins and furans. He also stated that these costs multiply quickly based on the number of samples to be tested. As a way to potentially avoid costs, he indicated that one could do composite, versus discrete, samples of sediment or water column.

3.1.3 Contaminated Water Diving Risk Characterization Framework

Presenter: Rob George, PhD, NIWC Pacific

Summary:

Dr. George provided an overview of the risk characterization framework and the goals of the workshop.

The workshop goal statement was the following:

Formulate the data and information requirements for using a risk characterization approach to determine the impact to divers from contaminants of concern, which can be applied at any given site and dive scenario, for purposes of addressing or mitigating potential risk.

At the beginning of the presentation, Dr. George asked a rhetorical question, "What is it that we should be concerned with?" and highlighted the importance of understanding the risk even if one ends up accepting the risk or uncertainty surrounding the risk. He provided example images of divers conducting various operations to highlight potential scenarios where a diver may be too conservatively protected or may be inadequately protected for certain situations. He acknowledged that it is often too difficult to tell from only visual inspection and acknowledged that the underwater environment is complex with many unknowns that may impact risk.

Dr. George then provided a diagram of how one might address the risk to any given contaminant of concern. He worked backwards through the diagram, starting with risk mitigation, and stated that one could avoid the risk, employ protection against the risk, or remove the source of the risk. He stated that in order to do any of these, you first need to assess the risk. In order to assess the risk, you need to characterize the risk, which requires characterizing the dive site, diver, contaminant of concern, the exposure, and the effects of exposure, which may have dependencies with one another. He then stated that the workshop should focus primarily on the aspects of risk evaluation or assessment using a risk characterization framework for any given contaminant of concern.

Following this, he also highlighted risk communication and risk acceptance, but emphasized that you want to understand what it is that is being accepted. In practice, he stated that a tool is needed to understand the risk and that a conventional approach would be the use of a risk characterization matrix. He provided an example risk characterization matrix graphic that captured how "Likelihood of Exposure to a contaminant of concern" is related to "Possible Consequence of Exposure to a contaminant of concern."

Lastly, Dr. George concluded with a list of assessment requirements and dependences that needed to be understood in order to conduct a risk level evaluation. These were demarcated into the following categories, for further discussion at a later point in the workshop:

- Consequence
- Contaminant of Concern
- Exposure
- Likelihood

Discussion:

Following this presentation, Mr. Sheldrake offered some thoughts on the framework.

He stated that that the EPA acknowledges a certain level of unknown and that it would be ideal if they were able to use all of their contaminants. From a practical perspective, they are rarely able to characterize a site to that level of detail and have to observe the site. As an example, the EPA would increase protection level within a harbor, such as that of United Arab Emirates, absent any testing. He stated that the testing, from an EPA perspective, would be useful in making the decision to go to a maximum level of protection. He also stated that he would turn the workshop around from an EPA perspective, with the idea that a contaminated site serves as a rebuttable assumption that testing can prove otherwise. With that assumption, he stated that they would have mid-level protection, i.e., full-face mask, decontamination compatible suit and gloves, and would then assess to see if they need to upgrade further. He also reminded participants that we should not forget about the dive tenders.

Dr. George agreed with that approach in the absence of adequate information, and stated that the big caveat is that you only do a risk characterization matrix with what you know or what you can get quickly to help decide. Dr. George stated that, from a DoD perspective, while information may be available, it is not necessarily used.

3.1.4 Occupational Exposure Risk Characterization Issues for Navy Divers

Presenter: Paul Gillooly, PhD, MSC, CAPT, USN Ret, NMCPHC

Summary:

Dr. Gillooly provided an overview of occupational exposure risk characterization issues for Navy divers from his perspective as an Industrial Hygiene Officer and as a Senior Risk Communicator for the Navy/Marine Corp. He provided insight in occupational health policies, resources, risk perception, risk communication, and gaps/areas of improvement for conducting risk assessments in the context of contaminated water.

Dr. Gillooly referenced two human health risk assessments taking place in Jebal Ali and Djibouti, and stated that they are typically focused on exposures above the water. For above water, Dr. Gillooly stated that they would first conduct industrial hygiene workplace exposure assessment, which entails surveying and measuring exposures. That data is then provided to Occupational and Environmental Medicine, who decides on the type of medical surveillance that will occur for those exposed to the hazard. He also stated that there are policies and resources in place that describe what it is and how to do it. The policies and resources referenced are the following:

- NAVOSH Program Manual (OPNAVINST 5100.23)
- NAVOSH Program Manual for Forces Afloat (OPNAVINST 5100.19)
- Environmental Readiness Program Manual (OPNAV M 5090)
- Deployment Health Procedures (DODI 6490.3)

Dr. Gillooly then discussed the exposure recordkeeping systems: Defense Occupational and Environmental Health Readiness System (DOEHRS) and the Individual Longitudinal Exposure Record (ILER). For the Department of Defense, DOEHRS is the system of record for recording exposures to workers. The new ILER is a combined Department of Defense and Department of

Veteran Affairs system intended to serve as a cradle-to-grave exposure record for DoD service members during and after service.

Dr. Gillooly then identified areas that he believes could be further improved. These included the following:

- Specific exposure/risk assessment guidance/framework for in water exposures, e.g., storm water exposures
- US and Overseas Water Quality Database, particularly for site-specific pre-dive assessments
- Defined hierarchy of controls for risk management

Dr. Gillooly described how exposure assessments are conducted for divers currently, and emphasized that these assessments are limited to above-the-waterline exposures. He further elaborated that there is good data regarding exposures/health hazards above the waterline through industrial hygiene exposure monitoring and medical surveillance; there is poor or limited data regarding potential exposures/health hazards, as there is no industrial hygiene monitoring and insufficient guidance/policy on how to make risk management decisions for divers. The overarching message was that Navy divers are often operating with limited awareness regarding potential chemical, physical, or biological hazards that cannot be observed with human senses.

Dr. Gillooly then provided key data gaps when conducting an exposure assessment. The gaps are the following:

- No centralized water quality database available for potential dive sites (especially overseas)
    - Routine water quality indicators are often unavailable
    - Surface water/sediment sampling with a focus on potential Navy diver exposures is excluded from many Occupational and Environmental Health Site Assessments
    - Chemical and biological data are typically unavailable
- Infrequent use of screening tools in the field for real-time water quality assessment
    - Tools are readily available for routine water quality parameters but less so for chemical/biological parameters
    - Very difficult to find DoD certified, fixed labs overseas
- Lack of policy, guidance, and funding for data collection on a regular basis to monitor water quality

Following this, Dr. Gillooly discussed risk perception and risk communication. He stated that there is virtually no correlation between ranking of hazards by experts and the ranking of those same hazards by the public, and that emotions tend to dominate the perception of risk over the facts. He also stated that there were three factors when perceiving risk. These factors are control, familiarity, and benefit. For divers, he suggested that they cannot necessarily exercise control on whether they dive or not; tend not to be familiar with science of the chemicals or contamination they are diving into; nor is there any direct benefit to their health. They may perceive benefits to the overall mission.

Also, he discussed the "CSI effect," which gives an individual a false expectation about what is possible. An example of this would be a diver acquiring an environmental sample and then wanting the following:

- Knowledge of what that they were exposed to
- Understanding of the exposure's impact on their health presently and in the future
- Immediate update to their health record incorporating the information

Dr. Gillooly concluded that winning with risk communication is different, and that a win could simply be a diver listening to the explanation of the science and accepting that.

Discussion:

Following the presentation there were several topics of discussion, which are delineated below as D1-D3.

(D1) One item of discussion that arose during this presentation concerned the idea of support personnel as it relates to continuous presence and temporary presence. Dr. Gillooly discussed the issues of expeditionary bases versus fixed naval bases. He stated that expeditionary bases do not have the same level of support and elaborated that the expeditionary bases operate with a different set of rules. He provided an example of characterizing occupational environmental exposures or conducting Occupational Environmental Health Site Assessments. These assessments must be requested by the Combatant Commander. In addition, these assessments are conducted differently using Military Exposure Guidelines that are based on much briefer exposures. In regards to this, EOCS McVicar mentioned an additional category to be considered: locations with minimal or no established structure where a few dives are conducted before returning. Dr. Gillooly acknowledged that those types of dives will be difficult to assess. In addition, Dr. Gillooly mentioned that sampling and analysis is difficult due to identifying laboratories capable and certified to measure the analytes, which leads to potential issues of preserving and shipping samples to the United States. Mr. Sheldrake followed up on this by stating that, with expeditionary bases, there may not be data available immediately, but one can envision that a few years down the line with an adequate database that the data could be provided for posterity.

(D2) Following this presentation, Jacob Goodwin asked if a list of contaminants would be made available and suggested that it would be helpful in developing technology to understand what contaminants need to be detected immediately and what contaminants would be potentially useful to know about after the dive. Dr. George stated that a list of chemical classes to analyze could be made available, but ultimately what is analyzed is site-specific.

(D3) Mr. Sheldrake commented that there needs to be better communication between medical and dive personnel. He suggested a feedback loop where information discerned through, as an example, a customized liver panel could be relayed to divers or tenders to help them understand how well they were protected during the dive or decontamination process.

Dr. Chimiak brought up the point of psychological impairment where a slight possibility of a chemical or bacterial agent may illicit an emotional response. He provided an example of decompression neurosis where a diver mistakenly believes they have the bends. He suggested that a diver may link conditions not associated with diving such as constitutional impairment to an

exposure to a toxin even if that is not the underlying reason. He stated that it may be difficult to correlate the results of a liver panel, which may be indicative of hepatitis, as opposed to an exposure while diving. Mr. Sheldrake explained that it is standard practice at the EPA to document daily exposure history and the severity of exposure. He explained further that part of their medical surveillance conducted for OSHA 1910.120 is, if an individual had 30 days or more of exposure, the EPA customizes the blood panel and urine work. He provided an example where, if an individual is working a site with arsenic or lead, they would look at urinary arsenic or lead in blood. He also acknowledged that there may be confounding factors that should be communicated.

Dr. Giloolly made two points. The first point was that there is a data repository and there is an organization dedicated to collecting health data called the National Center for Medical Intelligence. The second point was that individuals conduct pre-deployment and post-deployment questionnaires, which include what you may have been exposed to. He stated this exposure is not quantitative so it may not be helpful for the physicians later on.

Further, LT Comer stated that their Undersea Medicine Officer looked into documenting potential exposures. He stated that they are using Medical Matrix Online to produce SF-600 forms to help determine what blood tests they should do. He stated that it is relatively simple for individuals to do.

Dr. Philippi elaborated more on the medical matrix, which is one of the missions of the Navy Marine Public Health Community (NMPHC). He stated that the tests are basic screening and not as rigorous as what the EPA is doing. He explained that this is because there are very few diseases or conditions that have a specific biomarker, such as arsenic. He referenced that it is important to document a complete exposure pathway.

Mr. Sheldrake suggested that it is important to consult with the medical diving officer on what type of tests might be available to measure different contaminants. For example, if exposure to a pesticide is suspected, what level of concentration exposure might be measurable in cholinesterase test? He also suggested that it may be necessary, if the physician is predominantly focused on hyperbaric medicine, to consult with individuals who specialize in toxicology.

Dr. Chimiak emphasized that acute exposures to certain chemicals may be easier ascertained through these tests and relayed that understanding chronic exposure is a more difficult task.

3.2 ORGANIZATION INTRODUCTIONS AND CWD PERSPECTIVES

Once the initial problem and workshop focus was defined, a representative from each organization gave a brief introduction to their organization and discussed CRUD concerns from their perspective. Prior to the meeting, workshop attendees had been asked to prepare a 10-minute presentation that introduced and provided an overview of their organization as it relates to contaminated water, particularly from a risk-based perspective. Presenters were asked to include: (1) a statement addressing why they had an interest in this important issue, (2) a synopsis of information/insights that describes the type and magnitude of the issues they may be facing, (3) what actions they have taken, (4) other potential solutions considered to address those concerns, and (5) if possible, to identify uncertainties or areas in which they have the least amount of confidence, or greatest challenges regarding contaminated water. Similar to the earlier sessions, all presentations were unclassified, open/shareable level, and are available to all CRUD Stakeholders on the CRUD Stakeholder working group share site (https://wss.apan.org/navy/CRUD/default.aspx). Presentation and discussion summaries are provided below. Where possible, subheadings have been added to delineate different topic areas.

3.2.1 Title: Defense Threat Reduction Agency (DTRA) - Research and Development

Organization: Defense Threat Reduction Agency

Presenter: Don Cronce, PhD

Summary:

Dr. Cronce provided a brief overview of DTRA and the Threat Agent Science team. The focus of this team primarily deals with advancing and emerging threats from both the chemical and biological side. For these threats, the team conducts analyses to understand the chemical or biological agent's general characteristics such as, how it is synthesized and potentially disseminated, and how long a chemical or biological agent may last in the environment. Specific to biological agents are analyses that seek to determine whether the agent will survive the dissemination technique, and whether the agent will remain virulent once settled on the ground or in the water. Dr. Cronce stated that some of the chemicals can get into groundwater, lakes, streams, rivers, or other bodies of water in which divers may operate. Some of the questions that they study are: will the agent dissolve in water; will the agent breakdown; how long will it take to breakdown; is there a difference between fresh or salt water. As it relates to specific contaminants, Cronce stated that DTRA may be working on similar agents and could provide information on understanding the contaminants, the threat they pose, and what could happen if exposed. He provided an example of marine toxins.

Discussion:

(Q1) How does one gain access to the information collected by DTRA?

(D1) Dr. Cronce stated the easiest way to access this information would be to e-mail him. He also referenced that DTRA was working on a repository accessible to government personnel with a planned operational date of first quarter of fiscal year 2021. In addition, the information acquired on the agents is distributed to other programs supported by DTRA and that one way to potentially get diver requirements addressed is to communicate with the Navy representatives on the Chem-Bio Defense Program working groups.

3.2.2 Title: Royal Australian Navy

Organization: Royal Australian Navy

Presenter: CDR Douglas Falconer

Summary:

CDR Falconer provided a brief overview of contaminated water diving perspective in Australia. He stated that this has become more of an issue in Australia due to the wildfires and floods of 2020, which contributed to increased pollution in the waterways. In addition, there was a helicopter accident where the aircraft crashed into a lake, which led to an increase in contamination in the body of water from oil and fuel. Further, the Australian Army probably holds the majority of dives in regards to contaminated diving due to engineering and waterway diving, e.g., lakes, dams, and creeks. Also, the forensic and police forces do a significant portion of the blackwater environment dives. Furthermore, CDR Falconer relayed that in Australia you need to account for environmental stressors such as temperature, and other hazards such as crocodiles in northern Australia.

Discussion: none

3.2.3 Title: US Coast Guard (USCG) Contaminated Water Program

Organization: United States Coast Guard (USCG)

Presenter: CWO Joe Erwin

Summary:

CWO Erwin provided a brief overview of USCG diving. The USCG conducts dives all around the world and are trained by the DoD. As an anecdote, CWO Erwin described how he ended up contracting a Methicillin-resistant Staphylococcus aureus (MRSA) infection during diving school as he was quickly changing out the dive suits without conducting any decontamination procedures. CWO Erwin stated that USCG divers predominantly dive in ports. The USCG conducts missions related to emergency underwater ship husbandry, aids to navigation, environmental protection and natural disasters, oil spill support, and polar ice breaker support. He then described some of the equipment that they use, including: SCUBA, side scan sonar, handheld sonar, remote operating vehicles, and cold-water ice diving (one of their specialties). He also stated the USCG divers can operate in CAT-2 (heavily contaminated water). Following this, CWO described the USCG Pacific strike team and stated that they were exceptional at industrial hygiene, occupational medical surveillance, and knowledgeable in regards to chemicals. In addition, he stated that anyone can request them to assist with contaminated water operations and decontamination.

Capability/Data Gaps:

CWO Erwin then referenced a number of work groups/exercises that they have conducted and listed a number of outcomes for these. The identified needs from these work groups/exercises were:

- Standardized equipment
- Medical monitoring
- Expeditionary water sampling
- Standardized training (e.g., Hazardous Waste Operations and Emergency Response (HAZWOPER), Hazardous Material Incident Reports, and Army school with full mission oriented protective posture gear)

Operations example:

CWO Erwin described a mission to a swampy area where there previously had been an aircraft crash. He described some of their risk management planning, which included:

- Testing an old water sample
- Socializing the sample with the Pacific Strike Team's industrial hygienist
- Identifying what would be acceptable diver dress for the mission
- Endurance medical monitoring
- "Go/No-Go" decision making

Discussion: none

Potential Resource:

CWO Erwin mentioned their Strike Team's comprehensive laboratory examination and offered this as a resource for how dive lockers could potentially conduct an initial evaluation of a new contaminated dive site.

3.2.4 Title: EPA's National Underwater Diving Safety Management Program

Organization: United States Environmental Protection Agency (EPA)

Presenter: Mr. Sean Sheldrake

Summary:

Mr. Sheldrake provided an overview of the Environmental Protection Agency's Diving Safety Management Program with an emphasis on contaminated water diving. He initially provided an overview of the different levels of divers at the agency, based on experience (i.e., trainee, scientific, and divemaster). Furthermore, he stated that the EPA currently has about 60 divers, which is similar in size to other civilian dive programs, such as the Forest Service, Geological Survey, and the Department of Fish and Wildlife Services. The EPA conducts about 1,400 dives per year. There are ten regional units throughout the country, but only one—the New Jersey unit—does dives throughout the United States and its territories, due to its emergency response charter.

Mr. Sheldrake then presented the focus areas of the EPA diving. These include survey and sampling, criminal enforcement investigations, research and monitoring, and emergency response.

With regards to survey and sampling, the EPA does the following:

- Conduct habitat surveys where they look at contaminated media and inform project managers about what type of cleanup is necessary at the sites
- Monitor offshore disposable sites where dredged material is deposited
- Conduct examinations of groundwater moving from contaminated sites into rivers, estuaries, and oceans
- Examine the pore water and sediment to determine if sites need to be remediated
- Collect live biological samples to further understand the relation between sediment and surface water
    - Example: Clam and mussel sampling can be used as an indicator for contamination burden as they act similarly to a passive sampler.

Operation example:

The EPA conducts a majority of its dives in harbors. In this case, the question is not if the harbor is contaminated, but to what extent it is contaminated. In light of this, that is the focus of the EPA's site assessment/chemical testing. He also alluded that, if certain industries are within the harbor, then a list of chemicals could be generated. Because of their emphasis on contaminated water diving, the EPA has a fairly aggressive medical surveillance in terms of frequency of examinations.

Types of equipment that the dive units include primarily SCUBA with full face masks, but some units are equipped with surface air supply with helmets. They also contract out a significant portion of the contaminated category diving work due to logistical and space concerns, but they do emphasize the use of contaminated water diving gear for contractor divers.

Following this, he described the EPA's current focus areas, which include integrating light work diving for mission work, as well as continuing outreach to commercial, public safety, scientific, and federal dive communities on contaminated water training, medical surveillance, and tools available for dive planning. Other focus areas include medical monitoring related to contaminated water diving, improvements of decontamination techniques, personal protective equipment, and resources for polluted water diving.

Resources:

He then described a geographic information system (GIS) dive planning tool that they use in some of their regional offices. The tool integrates GIS data to provide information on Clean Water Act 303(d) listed waterbodies and the reason for impairment. This information could be included in the dive plan as well as measures that could be taken to combat the risk.

Discussion:

(Q1) Is the EPA only focused domestically?

(D1) Mr. Sheldrake responded that they are primarily focused on sites within the United States and its territories. He stated that, although the focus is domestic, that does not necessarily mean it is not translatable internationally. For example, a combined sewer overflow or disaster event would be similar whether domestic or international.

CAPT Murphy stated the latest revision of the Contaminated Water Diving Manual includes reference to EPA websites and resources for dive teams to access.

Mr. Sheldrake responded , with the GIS tool, you could build it for the contiguous US then replicate it with available information collected from overseas or from one's home country. Mr. Sheldrake also stated that the GIS tool is open source and that they have GIS technicians to help anyone begin using the tool.

(Q2) What thresholds does EPA use to dictate a switch from one categorical dress level to another level of protection?

(D2) Mr. Sheldrake stated the EPA does not have any precisely defined lines, but they would recommend a standard recreational diving site with a contamination risk of 1 in 100,000 cancer risk to upgrade their divers to a full-face mask, dry suit, and dry gloves. For risks identified as 1 in 1000 to 10000, they would upgrade the PPE to a helmet. He recommended that dive lockers have a set minimum level of protection that can be upgraded as needed as water can go from clean to filthy rapidly. Example referenced was a 2006 Sewage Spill in Hawaii.

(Q3) How were the cancer risks calculated?

(D3) Mr. Sheldrake referenced the "Diver Exposure Scenario for Portland Harbor" as a good example to describe methods. He also stated that a toxicologist could generate a simple spreadsheet that could be used to calculate the risk.

3.2.5 Title: Contamination Risk for Underwater Divers

Organization: Divers Alert Network (DAN)

Presenters: Drs. James Chimiak and Frauke Tillmans

Summary:

During this presentation, Drs. Chimiak and Tillmans presented an overview of the Divers Alert Network (DAN), including its mission.

DAN's mission is to help divers in need of medical emergency assistance and promote dive safety through research, education, products, and services. He also emphasized that DAN leverages a large network of experts in situations where they cannot provide an answer. He stated that DAN has been identifying and quantifying risk since the advent of the organization with particular emphasis on decompression and direct diving type problems. Furthermore, he spoke of how quantifying and measuring risk and conducting medical surveillance on divers for acute and long-term exposure risks is as complex and difficult as diving may get, as there may be other confounding factors that can affect an individual's health (e.g., cancer).

Operational Examples:

Following this, Dr. Chimiak described his Navy background and a number of historical examples from the Gulf Wars where chemical protective dive dry suit or a "double bagged suit" was used, as it was thought that nerve agents were being mixed with petroleum products. He also mentioned that industrial hygienists are critically important to communicate with, as some agents may degrade or penetrate diving suits over short time intervals (i.e., on the order of minutes). Dr. Chimiak then mentioned that these charts may be found in earlier papers and that the use of a "double bagged suit" was to cover one product and then to cover the other product in order to prevent nerve agent transmission.

Dr. Chimiak further elaborated on the types of dives recreational divers are conducting. He provided examples where divers are going into mercury mines or exploring wrecks at test sites in the Bikini Atoll. He also stated that they get calls about algal blooms and bacteria. Concerning algal blooms, he mentioned divers cleaning aquariums where algal growth is present will have unusual symptoms.

Data Gaps/problems and challenges related to contaminated water diving:

- Understanding hazards
    - Qualified manned studies needed to understand short- and long-term impacts of hazard exposure
    - Suggested targeting specific closed groups that conduct repetitive operations, such as aquarium diving and hull cleaning
    - Submarine studies where low-level exposure is monitored over a prolonged period may be suitable template to understand impacts of exposure
- Reliable testing and identification of environmental contaminants

- Cost-effective safe protection
    - Needs to address the agent as well as dwell time
    - Needs to address the cost-benefit of decontamination versus discard of equipment
- Protection of topside personnel/tenders
- Medical surveillance
    - Need to conduct surveillance over a proper cohort of divers to identify both short-term and long-term health impacts to understand issue of causality where a health outcome, such as the development of cancer, may or may not be associated with an exposure

Following this, Dr. Tillmans presented on DAN's research department, which focuses primarily on human biology and physiology in the diving environment. She stated that DAN is worldwide organization and has expertise in diving injuries and incidents.

Resources:

DAN funds research that benefits the diving community.

Discussion:

(Q1) What does DAN have for incident reporting in the context of contaminated water?

(D1) Drs. Chimiak and Tillmans stated that DAN has three different reporting systems: fatality reporting, incident reports, and medical emergency line. For contaminated water incidents, the reporting system has an input for water quality and would be captured in a narrative. Dr. Chimiak stated it is difficult to determine environmental exposure as opposed to incidental infection.

3.2.6 Title: National Institutes of Health (NIH) and National Institute of Environmental Health Sciences (NIEHS)

Organization: NIH/NIEHS

Presenter: Chris Weis, PhD

Summary:

Dr. Weis provided an overview of the National Institutes of Health (NIH) and National Institute of Environmental Health Sciences (NIEHS). The NIEHS is primarily located within Research Triangle Park in North Carolina across from the EPA's Office of Research and Development, which provides opportunities for the NIEHS and EPA to work together closely. The NIEHS has three major ongoing efforts ongoing. The first is intramural research predominantly targeted to specific national problems. The second is extramural research, which is primarily used to fund academic research around the country. The third is the National Toxicology Program (NTP). The National Toxicology Program is a consortium of agencies including the NIH, Food and Drug Administration (FDA), and Centers for Disease Control and Prevention (CDC) that fund state-of-the-art toxicological research. The NTP takes recommendations and nominations from anywhere or anyone to conduct toxicological testing.

The NTP conducts work with DoD on alternative methods in toxicology. Dr. Weis stated the old method is primarily dosing studies of animals. He stated that alternative methods are using better models using human tissue and cells and deploying high throughput screening techniques. Through alternative toxicology approaches, the NTP is moving away from extrapolating from animal models and towards predictive toxicology using human cells to identify adverse outcome pathways (i.e., biochemical pathways that predict disease).

Potential Resources:

Dr. Weis mentioned several resources that may be beneficial to contaminated water diving research:

- National Toxicology Program
- NIEHS Curriculum Design for trainings
    - NIEHS designed the HAZWOPER training which is required under OSHA 1910.120
    - Provided custom training to individuals deployed to Africa for Ebola outbreak
    - NIEHS Worker Education and Training program may help customize program specifically for divers
- NIH Program addressing critical research gaps for emerging contaminants
    - NIH is tasked with identifying information, documenting the gaps, and designing a program to fulfill those gaps.
    - Being done in collaboration with other federal agencies including DoD.
    - Potential avenue to getting contaminated water diving interests addressed.

Discussion:

(Q1) What is the status of the emerging contaminants program?

(D1) Dr. Weis said that they are in the planning process for the program.

(Q2) What is the research focus of the alternative methodologies for toxicology?

(D2) The toxicology research is focused mainly on hazards, but also on identifying pathways for acute, sub-chronic, and chronic exposure.

3.2.7 Title: NOAA Diving Program

Organization: National Oceanic and Atmospheric Administration (NOAA)

Presenter: CDR Eric Johnson

Summary:

CDR Johnson presented on NOAA Dive Program. NOAA is the largest non-DoD dive operations in the Federal Government with approximately 350 divers that conduct a total of about 16,000 dives per year. They have 50 dive units, including 34 shore-based units in Hawaii and Puerto Rico, and 16

research vessels with dive units onboard. NOAA also has medical training programs for Diving Medical Teams and Officers. NOAA has working divers that do light work (i.e., not intensive repairs). The working dives are conducted in accordance with OSHA. Assignments within NOAA diving range from ships to land assignments, such as fisheries or sanctuaries. Under the NOAA Diving Control and Safety Board, there is also the Dive Center, which is located in Seattle, WA. Within the center are the Diving Program Manager, who manages the NOAA policy for diving and safety, and the Diving Medical Officer, who is a Public Health Service Officer. The Public Health Service provides medical officers who support ship deployments. In 2017, NOAA had approximately 350 divers. NOAA primarily conducts no decompression dives with open-circuit scuba except for rebreathers in Hawaii. The majority of dives are primarily scientific (60%). Working, proficiency, and training dives comprise the other 40%.

NOAA has an equipment program manager and a standardized equipment program (SEP). The SEP, which has been in place for 20 years, has the units use standardized gear which allows divers to readily swap someone else's equipment if theirs fails.

Example of Dive Operations/ Scenarios:

Types of dive operations include:

- Dives in polar regions (such as Alaska) from ships, small boats, or hydrographic survey vessels
- Dives in tropical regions
- Repetitive dives
    - Example: Three dives a day over the course of a month
- Shallow water dives
    - Tidal work
    - Fisheries and sanctuaries
- Deep-water dives with rebreathers
    - Biologic surveys in the Hawaiian Islands
- Blackwater dives
- Superfund site surveys (i.e., Lake Union)

NOAA was involved in the equipment developed for diving in polluted and in hot water environments in the late 1970s, but they no longer have those capabilities. As of 2004, they no longer support contaminated water diving, and it is now NOAA policy that "NOAA divers are prohibited from diving in contaminated water" and "qualified contract divers should be hired to dive in these conditions." NOAA has procedures if someone is exposed, but if any divers suspect that they will be diving in contaminated water, they will reach out to find a partner who can support it.

Major Concerns / Data Gaps:

CDR Johnson listed the main issues/concerns with contaminated water diving as follows:

- On-site determination of water contamination—which contaminants are present and what is the level of contamination
- Appropriate Personal Protective Equipment and decontamination procedures
- Medical response—immediate on-site as well as long term
- Medical monitoring—parameters to monitor and duration of monitoring
- Legal requirements—notification of divers, long-term monitoring, worker's compensation
- Federal employees versus contractors

Discussion: None

3.2.8 Title: Human Systems Directorate Overview

Organization: Office of the Under Secretary of Defense for Research and Engineering Support

Presenter: Ms. Jennifer Coughlin

Summary:

Ms. Coughlin presented on the Office of the Under Secretary of Defense for Research and Engineering (USDR&E), including the Human Systems directorate. She stated the USDR&E's mission is to ensure technological superiority across the Department of Defense and to bolster modernization. She then highlighted that biotechnology is currently a modernization priority. She also elaborated further that they survey the DoD to find gaps and identify technology areas to push forward.

Following this, Ms. Coughlin discussed the Human Systems Directorate and four areas that it oversees including:

- Human Sciences
- Medical and Life Sciences
- Environmental Sciences
- Regulatory Oversight

The environmental sciences vision is to understand the environment so that DoD equities and operations maintain lethality, despite environmental hazards and stressors, and are effective, compliant, and sustainable. Under environmental sciences, there are three sub-areas of environmental situational awareness including: sustainability, compliant military systems, and environmental hazard protection and mitigation.

Organization Capabilities:

Ms. Coughlin stated that the primary focus is on basic research, applied research, and advanced technology development. The organization is involved in coordination, collaboration, communication, and hold workshops in order to identify capability and gap areas that may be worth further investment. She discussed that there is ongoing coordination with the strategic environmental research and development program and also stated that there is interest in the development of alternative toxicological methods. She caveated that currently the focus is on per-and polyfluorinated substances (PFAS). She also stated that much of the push is in development of cost-effective technologies to assist with hazard characterization in a variety of environments.

She concluded that there is no environmental community of interest within the DoD at present, but there are number of small groups that examine some aspects of diving primarily on the medical side related to diving in cold water or other extreme environments.

Discussion: None

3.2.9 Title: Healthy Swimming

Organization: Centers for Disease Control and Prevention (CDC)

Presenter: Ms. Michele Hlavsa

Summary:

At the opening, Ms. Hlavsa directly stated that they are unaware of any diving-specific or scuba programs or activities, but that they do have the Healthy Swimming Program, which is a cross-center effort between the CDC's National Center for Emerging and Zoonotic Infectious Diseases and National Center for Environmental Health (NCEH). The vision of the program is to minimize the risk of illness, injury, disability, and death associated with swimming.

Ms. Hlavsa then provided an overview of NCEH harmful algal blooms (HABs) activities. This included laboratory activities to develop methods to detect cyanotoxins in clinical specimens and epidemiology, and toxicology activities, such as studying CyanoHAB aerosols, exploring use of electronic health records, and enhancing the quality of poison control center data. As the CDC is not a regulatory agency, it relies on partnerships with state and local agencies. Concerning HABs, the CDC has partnered with the American Association of Poison Control Centers. She further emphasized that there are vast numbers of partners when it comes to untreated recreational waters.

- Division of Environmental Health Science and Practice (DEHSP)
    - Assists in coordinating responses to controlling exposures to chemical contaminants and releases and in gathering resources from the Agency for Toxic Substances Disease Registry, as well as within Environmental Health
    - Chemical Demilitarization Group, who has worked with DoD in removing munitions that can pose risks to divers
- Division of Laboratory Sciences
    - Ability to detect a wide range of contaminants in human specimens. They do not do environmental sampling and analysis, but instead do biological testing for chemical exposure

CDC Operation Process: To promote healthy swimming, the CDC takes four steps:

1. Analyze and publish national surveillance data. The primary surveillance systems are the National Outbreak Reporting Systems (NORS), the One Health Harmful Algal Bloom System (OHHABS), and National Case Surveillance, where they look at individual cases caused by a particular organism (e.g., *Naegleria*).
2. Conduct behavioral, environmental health, epidemiologic, and microbiologic studies, which are guided by the tracking or surveillance data.
    a. Example provided: behavioral research shows that swimmers think that it is harmless to swim while they are experiencing diarrhea, which then leads other swimmers ingesting the water and becoming ill. From the environmental health research, more than 12% of routine pool inspections result in immediate closures due to insufficient chlorine in the water or lack of safety equipment. From epidemiological studies, men tend to swim in untreated water, e.g., lakes and oceans, more than women. This research helps the CDC determine the when, who, and why people are becoming ill. To determine what is in the water, Ms. Hlavsa stated that the CDC conducts microbiologic studies. As an example, she stated that a recent study in Atlanta found that 58% of pools had E. coli present which means that there had been fecal matter in the pool.
3. Translate surveillance and study data into evidence-based communications.
4. Leverage the data into evidence-based policy.
    a. Example provided: For treated recreational water, the CDC has the Model Aquatic Health Code. The Model Aquatic Health Code contains recommendations to prevent illness and injury through design, construction, operation, and management of public pools. The US Environmental Protection Agency and states regulate untreated water bodies. The primary focus for the CDC is on treated water bodies because of the number of visits to pools exceed visits to lakes and oceans, less outbreaks associated with untreated recreational water, and greater difficulty in identifying outbreaks due to geographically dispersion as ocean and lake visitors tend to travel greater distances.

Scenarios/Operational:

Ms. Hlavsa provided several examples of current operational efforts that would be relevant to this working group, including:

- Untreated recreational water-associated outbreaks.
    - Over the period of 2009–2017, they identified 98 outbreaks that resulted in 4,542 cases and 80 hospitalizations.
    - The leading confirmed causes were enteric pathogens: norovirus, *Shiga* toxin-producing *Escherichia coli*, *Cryptosporidium*, and *Shigella*. The outbreaks primarily occurred in June through August.
    - From 2009–2017, there were only three ocean outbreaks reported. The responsible pathogens were campylobacter, *Shiga* toxin-producing *E. coli*, and an unknown.

    - In contrast, the reported number of outbreaks and cases for treated recreational waters was 335 and 6,300, respectively.
    - 30 states voluntarily report untreated recreational water-associated outbreaks, although states do not necessarily have an obligation to report outbreaks to the CDC. As such, outbreak reporting to CDC may not reflect true incidence of outbreaks in a given jurisdiction.
- Harmful algal blooms (HAB).
    - HAB toxins can cause human and animal illness through ingestion, inhalation, or dermal contact.
    - HAB have garnered attention as a "One Health" issue, which recognizes that human health is connected with health of animals, plants, and environment.
    - HAB are an emerging public health concern due to warming climate and nutrient pollution. From 2009–2017, there have been 14 confirmed or suspected outbreaks caused by cyanotoxins with 271 cases. In addition, the CDC launched OHHABS in 2016 to collect data on individual cases of human or animal illness and also on freshwater and marine HAB events. The first report on OHHABS data is expected in 2020.
- National Case Surveillance
    - Example: Naegleria fowleri. This particular pathogen enters through the nose into the brain, destroys brain tissue, and leads to brain swelling and death. It has a fatality rate of 97%. For this particular pathogen, 30 of 34 of the reported infections from 2009–2018 were associated with recreational water.

Discussion: None

3.2.10 Title: Smithsonian Scientific Diving Program

Organization: Smithsonian Scientific Diving Program

Presenter: Ms. Laurie Penland

Summary:

Ms. Penland provided a brief overview of Smithsonian Scientific Diving Program. General structure of program includes central diving and then diving units located in the United States and Central America. The diving program has approximately 100 divers and log about 3300 dives per year throughout the world and that the locations vary from year to year.

Ms. Penland then provided her purpose in attending and that was to learn how to identify and mitigate hazards to protect the Smithsonian divers. In addition, she provided a number of concerns which encompass the National Zoological Park, invasive species research, the Chesapeake Bay, and foreign locations.

Operational Examples / Scenarios & Concerns:

Ms. Penland provided several operational examples where different aspects of contaminated water diving were a concern including:

- Seal and Sea Lion Pool at National Zoological Park
    - Main concern was biological pathogens
    - Smithsonian divers conduct water quality tests at the surface and have divers wear full face masks
    - Occasionally, they also have NOAA divers assist
- Invasive species research where divers investigate ship hulls in highly trafficked harbors
    - Main concern from these operations are industrial contaminants within the harbors
    - No mitigation measures currently in place for this type of exposure
- Oyster surveys that have been taking place in the Chesapeake Bay for decades where divers conduct benthic sampling
    - Low visibility conditions where they shovel and collect substrate
    - Primary concerns were pathogens as well as toxins
    - No mitigation measures currently in place
- Diving in foreign locations with minimal or no regulations for collections and surveys
    - Usually one-time dives where they do not know much about the location in terms of contamination
    - Main concerns were pathogens, toxins, and industrial contaminants
    - Try to make the dives as safe as possible, but they do not have any procedures in place as far as contaminants in the water

Discussion: None

3.2.11 Title: EXWC Dive Locker RDT&E Efforts Contaminated Water Diving and Diver Temperature Control System Project Update

Organization: Naval Facilities Engineering and Expeditionary Warfare Center-Diving Unit

Presenter: EOCS James McVicar

Summary:

EOCS McVicar provided an overview of EXWC Dive Locker and a working divers perspective of issue. NAVFAC EXWC Dive locker is the Naval Expeditionary Combat Command's dive locker. They conduct research and development of tools and techniques for working divers to increase effectiveness of underwater construction teams and mobile diving salvage units. Currently, they are working on building a diver thermal control system. NAVFAC EXWC also hosted a contaminated water diving exercise with USCG and DoD participants and had success in practicing the use of the emergency ship Salvage material decontamination kits.

Organization capabilities:

Typical activities include:

- Construction operations: pouring concrete, demolition, dredging, inspection, digging, and welding
- Diamond wire sawing for salvage
- Underwater hydraulic tools
- Underwater navigation systems
- Equipment evaluation and test plan support for NAVSEA, USCG, and US Army
    - Diver Thermal Control System

Operational Scenarios/Examples:

EOCS McVicar provided several examples of impacts of contaminated water diving on sailors as well as his perspective as a diver.

Examples included:

- Sailors discharged from the Navy due to health issues ranging seizures, gastrointestinal infections, and thyroid issues.
- Individuals were getting pulled from the water due to flesh-eating bacteria infections.

When he discovered that there was this issue, he reached out to individuals in the Navy, EPA, NOAA, and USCG. He then started collaborating with USCG Pacific Strike Team. He investigated Port Hueneme harbor and found reports of Polychlorinated biphenyls (PCBs), arsenic, mercury, cyanide, cadmium, antimony, and hydrocarbon contaminants.

He provided an overview of the diver thermal control system.

Primary Needs/Concerns and/or Data Gaps:

Based on his experience, EOCS McVicar provided a list of concerns and/or data gaps, including:

- Need to be able to detect contaminants
    - Example: Use field deployable gas chromatography/mass spectrometry (GC/MS) instruments, which allow for a more extensive contaminant identification capability
- Need to protect both tenders and divers.
    - This includes suitable personal protective equipment for hot, tropical environments which are the impetus for the diver thermal control system
- Need to decontaminate

    - In order to properly do that, they need to know what they are decontaminating against
- Need for medical surveillance, documentation of exposure, and having that information placed in individual's record
- Making available information accessible and usable for divers
- If divers cannot be protected, make sure that they are taken care of by Veterans Affairs
- Even with data about contaminants uncovered at specific sites, there appears to be no one that can provide a good answer on how to best protect the diver

Discussion:

Q1: Is there a report from Coastal Trident 2019 Contaminated Water Diving Exercise (CONDIVEX)?

(D1) LT Comer states that he has a report summarizing the exercise and can share upon request.

(Q2) Where will you be testing prototype suit?

(D2) The discussion involved what types of testing will be done and cost of suit. Dr. Weis mentioned that NIEHS has small business grants available for developing apparel that would measure physiological parameters and suggested that it may be able to monitor heart rate and temperature during a dive.

Potential Resources:

- Sampling information is potentially available for sites such as San Diego, Little Creek, and Joint Base Pearl Harbor
- Coastal Trident 2019 CONDIVEX Report

3.3 DAY 1 AFTERNOON SESSION-GENERAL TOPIC AREA DISCUSSIONS

The goal of the afternoon session was to examine different issues/concerns associated with understanding the risks of operating in contaminated waters. To kick off the dialogue, general topic areas were raised, such as: risk communications, exposure concerns and potential consequences, different methods for how one might assess risk, and mission characteristics that might impact and/or influence overall risk.

While the initial intent was to step through each topic area systematically, the dialogue evolved into a more organic, free-flowing discussion. As such, transitions from one topic to another was at times fast-paced, making it difficult to identify who exactly was speaking and to capture all relevant comments. As a result, a general term of "participant" has been applied to each speaker to indicate changes in who was relaying information. In addition, where possible, similar topic area comments have been arranged under subtitles of specific topic areas discussed.

3.3.1 Topic Areas of Discussion

Dr. George initiated the afternoon session and one participant brought up a few risk evaluation/communication topics for consideration.

Risk Communication Gaps:

- How does one communicate to a diver that, if they do not have a completed exposure pathway, they will not have a health effect?
- How does one resolve issue where a diver does not necessarily want to self-report, as that might prevent them from participating in a dive?

Contaminant Exposure and Consequences:

During this discussion, participants suggested that it may be necessary to stratify exposure beyond acute and chronic. An example was given that acute exposure may be broken down further based on the ability to complete dive or the ability to complete a mission. It was also suggested that acute exposure consequences could be broken into urgent versus emergent based on symptoms.

Models for Assessing Risk:

Participants raised two different models that they use for assessing and understanding risk:

- Classic Risk Paradigm Assessment
    - Identify the hazard
    - Assess the dose-response
    - Assess the exposure
    - Characterize the risk to determine if it is acceptable or unacceptable
- Conceptual Site Model
    - What is the hazard or contaminant?
    - How is the hazard released?
    - How does it move from point of release to the receptor, i.e., diver?
    - What are the exposure routes, i.e., inhalation, injection, ingestion?
    - What are the consequences of an exposure?

The participant discussing the conceptual site model stated that this was what he considered the most important tool for assessing and communicating risk.

Another participant pointed out that the classic risk paradigm assessment has four parts. They are identifying the hazard, assessing the dose-response, assessing the exposure, and then characterizing the risk to determine if it is acceptable or unacceptable. This led to discussion on whether to tackle the process or focus on individual parts of it.

Another participant described a tool that they use and it is called a Conceptual Site Model (CSM) which goes from asking what is the hazard or poison? How it is released? How does it move from point of release to the receptor (i.e., diver)? What are the exposure routes (i.e., inhalation, injection, ingestion)? And, finally what are the consequences? An example he provided was standing on a barge and deciding for a diver who was going to immerse themselves in water contaminated with benzene or PCBs. He stated that the CSM was the first thing that they would do and stated that this was most important tool he had used for assessing and communicating risk.

Dive Site Characteristics and Diving Operations that might affect/impact exposure to Contaminants of Concern (CoCs):

One of the participants suggested that it may be helpful to examine specific scenarios. He provided an example of diving in benzene-polluted waters in the Great Lakes. Another participant suggested that USCG may know what hazards that they may be dealing with for particular scenarios as they may have (e.g., a ship manifest or equivalent), but that other organizations may not know what is present at a specific site. This led to the following questions being asked:

1. How do you decide what hazards to list?
2. How do we know that what the divers are doing is not good enough already?

The discussion primarily revolved around the first question about the decision on what hazards to list and the information that may be required.

One participant suggested that, once you have information on a particular hazard (e.g., benzene) at your site, you should evaluate the impact or consequence of diving in presence of the hazard at a certain concentration level. In addition, he suggested that if that information is not available, you should be assess your site to find information about it. Another participant stated that it is necessary to first parse and reduce the list of chemicals based on scenario (e.g., types of industries present) as the approach to evaluating every chemical that may be present would be intractable. In response to this, it was suggested that one may examine legacy types of contaminants that might be typically expected in a dive environment or that examining classes of chemicals may be a way forward.

Participants highlighted potential solutions:

1. Assessing sites using satellite imagery or by examining what industries are near a dive site to make assumptions on what contaminants to sample and analyze for.
    a. Example: Cement plants may be source of polycyclic aromatic hydrocarbons
    b. Example: Rocket fuel plant may be source of perchlorate
    c. Example: Closed waterbody may cause contaminants associated with accidental discharges to linger
2. Sampling and analysis at sites that may serve as guide on what should be sampled for or analyzed prior to a dive.
3. Capturing available data at your site, e.g., documents on legacy contaminants at site or port sampling program data.

4. Encyclopedia of chemicals accessible to divers that states how to test for it, where it's found, specific gravity, consequences of exposure, and what industries it is associated with.
5. A roadmap or tool that allows you to select a site, compile available information, and make assessment from that information.
6. Using senses and communicating with locals.
7. Sensors for monitoring environmental contaminants.

A participant also suggested that they are concerned with what may happen during a dive versus what is currently in the water.

Exposure/Medical Perspective:

Following the risk communications/exposure discussions above, a participant provided insight on how they would approach issue of exposure from the medical perspective. At bare minimum, he suggested that the following should be done in order to assist in future studies or medial surveillance:

- Capture duration of the dive
- Capture location of the dive
- Capture symptoms that they had

He suggested that it does not matter how many chemicals you have been exposed to as many do not cause any adverse health effects. He suggested that the most important aspect is if it causes some type of measurable clinical effect. Once you have this data you can try to determine what they were exposed to at a dive location.

This participant also pointed out that there are problems with interpreting environmental exposures. He suggested that the first problem is that the concentration of contaminants may be homogenous or heterogeneous, depending on the dive site. The second problem is that, just because an individual was exposed to it, does not mean it was absorbed and caused symptoms. In order to do that, profile monitoring would need to be done to assess for absorption and what type of physiological levels are present. Lastly, one would need to tie that absorption level to symptoms. He provided an example of a spike in volatile organic compounds in urine after pumping gas, but they do not have any long-term effects.

Case Studies/Scenario Examples:

A number of case studies or examples were presented throughout the afternoon discussions. These examples are itemized collectively here for convenience.

- One participant referenced the Israelis and what they are doing concerning cancer in their divers. They identified specific areas that they no longer dive in, particularly harbors. They

conducted long term monitoring on their entire dive program, isolated the areas, and increased PPE. He suggested that the Canadians are following suite.

- Another individual offered an anecdote on diving in the Middle East where divers shed their protective equipment due to heat casualties.
- An individual from USCG stated that they were having divers complain of skin rashes and irritable ear after trying to upright a boat in Hawaii. He suggested that they might have been better off wearing dry suits, but they would have needed to weigh risk-benefit of using it warm waters.
- A Navy diver provided anecdotes of divers having seizures, gastrointestinal infections, and thyroid problems. He also mentioned an example where a detachment of 12 individuals was pulled from water due to flesh-eating bacteria.
- A Navy diver provided an example of warm-water diving in a Viking suit and the need to be predictive of hazards in order to not have to wear it because there is an unknown.
- Someone mentioned a sunken Soviet Juliett-class submarine off Providence, Rhode Island that use to be a coal on-and-off load area. The divers experienced nausea and vomiting after working in the sediment. They were wearing semi-dry suits and the fix was to outfit them in dry suits.
- It is well-known to divers that if you spend long in mud you will come up tingling or dizzy absent of decompression sickness (DCS)-type environment.
- An example was provided that divers in Marshall Islands experience skin issues including Methicillin-resistant Staphylococcus aureus (MRSA) infections as well as nausea.

3.4 DAY 1 RECAP, IDENTIFICATION OF POTENTIAL DATA GAPS, SOLUTIONS, AND POTENTIAL RESOURCES

The closing session of day 1 involved a brainstorming session on what participants felt were potential data gaps in our current understanding, proposed solutions if known, and any potential resources that might be helpful to the community at large. It should be noted that some of the items/ topics summarized below may have been brought up earlier in the day, but have been moved to this section for organizational purposes. Similar to above, subsection titles have been added to help separate different focus/topic areas.

3.4.1 Data Gaps and Solutions

CAPT Murphy suggested that, from his perspective, there are two primary needs:

- An observation program established for divers that is looking long-term at the Navy diving community, similar to that of the submarine community.
- Protection of dive team now, which may include assessing a site or multiple sites for however long one will be in diving in that environment.
    - These steps may need to be repeated at the next place the diver goes as well

Highlighted gaps and potential solutions by topic area:

- **Environmental Intelligence Gap**
    - Single iIndividual or entity that is available to assist in providing information on a site as many deployed units are overtaxed and unable to investigate surrounding industrial areas or go through manual references and contacts
    - Information is either unavailable, not being provided, or is not easily accessible to divers
    - The analysis and what it means to the diver needs to be better conveyed
    - Information about the site (e.g., observations, types of operation, industry, etc.) prior to arrival if possible
    - Does not appear to be anyone responsible for sampling and analysis OCONUS

- **Environmental Intelligence Suggested Solutions**
    - Pre-dive/pre-plan assessment database to inform divers of contaminated water OCONUS. Most ports have some variation of a safe water act and are doing monitoring.
        - The data is available, but it may cost a lot to build a database with it
    - Sampling and Analysis Program
        - Suggested to be set up similar to centralized air compressor monitoring program where sample is collected and analysis is conveyed back to diver
        - In regards to populating database, someone suggests a cooperative interaction between diver and the entity maintaining the database. It is suggested that the entity that maintains the database be accessible to the diver such that the diver can reach out to an expert who can advise them. The entity in charge of the database can then reach out and send the diver a sampling kit or ask when they are done with the mission to report back certain data on the site. If it is not simple and easy for the warfighter, they are not going to do it. The idea is that there is an exchange of information where the warfighter helps to fill in gaps.
        - Some dive teams may be willing to assist in sampling ad-hoc but it should not distract from their primary job
            - Information feedback in order to be willing to do it
    - Emulate terrestrial hazmat
        - In absence of information, the level of protection is conservative until proven otherwise
    - Passive samplers
        - Provide time-integrated average
        - Potentially high development cost

        - Could be placed at dive sites or potentially on diver
        - EPA has shown interest in using for elicit dumping
        - Can be used potentially for polyaromatic hydrocarbons, polychlorinated biphenyls, heavy metals, and munition compounds
        - May be useful if diving at site for a long time
    - Citizens Science Projects that collect pictures or whatever can be collected at time
    - Mussel Watch Program, which can provide similar information as passive samples
    - Collect and collate information that may be available for diving sites
    - Creation of database of that provides current state of ocean contamination
        - Recommended compiling information from EPA for CONUS
        - Leverage EPA GIS Tool with known impaired waterbodies
            - Provides a list of chemicals and/or coliform levels for these bodies.
            - Information can be gathered and inserted into dive plan.
            - Minimal need to change the dive plan at that site unless there were new laws and/or information regarding changes of level of discharge

- **Reporting, Tracking, and Medical Surveillance Gap**
    - Example: Divers only report problems when they are tired of dealing with an issue. If they are reporting the issue, it is supposed to documented with a corpsman who then enters that information into a computer system. If it is not getting reported, then it conveys that the divers do not believe the rashes to be that bad. In theater, not all medical information gets entered into this system or it may be a paper medical record. Currently, the US Navy is trying to implement reporting and tracking for acute symptoms in order to be able to make interventions.
    - Lack of assigned Undersea Medicine Officers at dive lockers.

- **Reporting, Tracking, and Medical Surveillance Solutions**
    - Report information into Dive Jump Reporting System
    - Defense Health Medicine is consolidating the Navy and VA medicine. The lone product line is now public health or industrial hygiene, so the surgeon general of the services may be receptive especially if it is a readiness issue

- **Accessible Database Gap**
    - Example: Once hazards are identified, there is a need to access a database, request a list of the hazards to be concerned about, and the levels that make a difference in what type of gear you use or not use

- **Sensors and Analysis Gap**
    - Example: Are the potential hazards actually hazards? This may require sampling and analysis of contaminants present in very low concentrations.
    - Most sensors for low concentrations measurements are expensive
    - Most sensors are specific versus broad
    - Preference is now what's present before diving
- **Sensors and Analysis Suggested Solutions**
    - Sensors are being developed for near real-time, point-of-need sensing that may be beneficial when a diver does present symptoms
    - On-person physiological or environmental monitoring
        - Current diving sensor projects for physiological monitoring include electrocardiogram belt, functional near-infrared spectroscopy helmet, and pulse oximeter
    - Passive samplers
        - Provide time-integrated average
        - Potentially high development cost
        - Could be placed at dive sites or potentially on diver
        - EPA has shown interest in using for elicit dumping
        - Can be used potentially polyaromatic hydrocarbons, polychlorinated biphenyls, heavy metals, and munition compounds
        - May be useful if diving at site for a long time
    - Paralenz, a Denmark company, has camera that can take pictures, measure dive profiles, temperature and potentially salinity
    - Mussel Watch Program, which can provide similar information as passive samples
    - Identify and sense surrogate compounds as opposed to detecting all contaminants that may be present

- **Health Data Collection Gap**
    - Does not appear that we are collecting data to make connection between exposures and human health
    - Sandra expressed concern about epidemiology study: Only as good as the data available, and the existing data is not good enough and thus may not get the Navy Bureau of Medicine and Surgery BUMED to institutionalize it.

- **Health Data Collection Suggested Solutions**
    - There is toxicology data from NIH, CDC, and DTRA with connection points to human health
    - DAN collects health data
        - DAN states anyone can call them and that they will put the information in their database
        - Captures symptoms such as dermal infections
    - Suggestion that divers should be longitudinally monitored for 20 – 30 years

- **Training and Equipment Gap**
    - Encounter category of contaminated water OCONUS but are not trained to use or do not have the suggested equipment
    - Current high-level protective gear appears to be protective against most threats but appears to be restrictive and limiting
        - Diver suggests that you really have to be persuaded into one and requires significant time to become competent with suit
        - Current dry suits have risk of thermal casualties in warm water
    - Divers may be occasionally wearing too conservative of equipment

- **Training and Equipment Suggested Solutions**
    - Pre-dive/pre-plan assessment database to inform divers of contaminated water OCONUS. Most ports have some variation of a safe water act and are doing monitoring.
        - The data is available, but it may cost a lot to build a database with it
    - May be possible to engineer away thermal issues (e.g., diver thermal control system)

- **Policy Gap**
    - What is the acceptable level of risk for the organization or mission?
        - May depend on urgency of mission
        - EPA leans towards the side of caution and attempts to mitigate lifetime cancer risk

3.5 AVAILABLE TRAINING AND RESOURCES

Finally, the topic of availability of training and different resources was discussed.

Availability of Training and Equipment Concerns

One participant asked about dive teams deploying OCONUS. He asked about what happens when they encounter a category of water and do not have the right equipment. A diver stated that they have CAT I, II, and III water. They have CAT I water, but do not have recommended PPE, and stated that this may be due to ignorance and also to lack of technology.

The participant further stated that he had conversed with another diver previously, and that the diver stated that water was categorized to certain level prior to deployment but they were not trained nor able to dive with the recommended equipment for that category of water.

CAPT Murphy suggested that this identifies a number of issues:

- The diver needs to reach back and ask, how do I protect myself?
    - With the equipment the diver does have, they should offer recommendations on what the diver should wear
- The diver should reach back about any equipment or training issues
    - The diver needs this equipment. How we can help get them that equipment?
    - The other issue is that they need to account for what equipment is available and if it would be able to be incorporated
- The diver needs to have information available in order to dive in the "know" and understand what equipment or training is needed to respond to their environment
- The diver needs to be aware of routes of exposure and to take precautions against them
    - Most teams take precautions against ingestion and inhalation, but are hesitant on dermal absorption

One participant pointed out that wetsuits during a mud-dive will collect a fine layer of dust when they dry. By just wiping it, it may lead to digestion exposure for diver or tender.

Another participant asked if the divers could absorb the responsibility of episodic sampling. In response, one diver suggested that his team would be onboard if it took a minimal level of training. CAPT Murphy suggested that they may encounter resistance as episodic sampling may detract focus away from the divers' primary job. Nevertheless, he further stated that if the divers were receiving feedback from the sampling, the divers may be more amenable to it as they would be reaping the benefit.

3.5.1 Potential Data Resources

The following data resources were mentioned throughout the course of day 1 discussions:

- Epidemiological Israeli study of divers
- USCG stated that they may be able to assist with water samples at ports
- Guidance for diving gear versus temperature that may provide stay times at certain temperatures
- US Navy passive monitor program for submariners
- Data sources and environmental reports may be available from US Army Corps of Engineers, NAVFAC, Commander, Navy Installations Command CNIC for Yokosuka or Pearl Harbor
- EPA GIS Tool that provides a starting point for domestic bases
- EPA Integrated Risk Information System (IRIS)
- EPA National Pollutant Discharge Elimination System (NPDES) Program
- Navy Public Health risk assessment project in Jubal Ali that may be adaptable to other situations

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4. DAY 2 OF WORKSHOP

The primary focus of day 2 events was to recap findings from day 1, provide CRUD stakeholders an opportunity to highlight significant findings from their own individual perspective, as well as identify future actions.

4.1 ADDITIONAL ORGANIZATION INTRODUCTIONS AND CWD PERSPECTIVES

Due to scheduling/availability issues and expressed interests by participants, two organizations and one example of an emergent sensing technology was presented on day 2. Similar to day 1, all presentations were unclassified. All open/shareable presentations are available to all CRUD Stakeholders on the CRUD Stakeholder working group share site (https://wss.apan.org/navy/CRUD/default.aspx). A brief summary of each presentation and subsequent discussions are provided below. Where possible subheadings have been added to delineate different topic areas.

4.1.1 Title: Diver Health and Epidemiology Program (DHEP)

Organization: Naval Sea Systems Command (NAVSEA)

Presenter: David Southerland, PhD

Summary:

Dr. Southerland provided a short brief on the Diver Health and Epidemiology Program (DHEP) at the Naval Submarine Medical Research Laboratory (NSMRL). The purpose is to conduct a longitudinal, population-based health study of approximately 10,000 US Navy divers. It is a three-year project. The study is a retrospective study of divers and will leverage available data within the DoD. NSMRL will build a Navy diver database by linking additional databases to the Undersea Health Epidemiology Research Program database. They will perform subject linkages across the databases to assess and compare injury rates and location-specific medicals for comparison with divers and non-divers. Finally, they will document the full spectrum of injuries and illness among these divers over a ten-year period.

The databases being planned are from Defense Health Agency, Military Health System, Naval Safety Center, Bureau of Medicine and Surgery, US Submarine Service Center, Defense Manpower Datacenter, and Bureau of Naval Personnel.

The main outcomes anticipated are to identify risks by dive location, to identify any increased prevalence of certain conditions such as skin or pulmonary, and to have a full spectrum of injuries and illnesses of current or recently separated divers over a ten-year period.

Discussion:

(Q1) A participant asked if any of the Veterans Affairs (VA) data or records feed into databases that will be used in the surveillance study as this would pertinent for diseases such as cancer.

(A1) Dr. Southerland states that he does not believe that any VA data is being used as part of the study.

(Q2) A participant asked if there would potential in taking a preliminary look at where the dives were done to potential link the health information to number of dives or to particular sites.

(A2) Dr. Southerland responded that the Dive Jump Report System changed in 2019 to incorporate contaminated water reporting, but that one be able to communicate with the "Master Diver Network" to find out that information. A participant suggests that one might want to do this independently of being identified or tagged as a contaminated water dive.

4.1.2 Title: US Navy Experimental Diving Unit

Organization: US Navy Experimental Diving Unit (NEDU)

Presenter: Mr. Vincent Ferris

Summary:

Mr. Ferris provided a summary of the US Navy Experiment Dive Unit (NEDU) and its facilities. The NEDU is a field activity of NAVSEA Supervisor of Diving and Salvage. A number of facilities at the NEDU were presented:

- Ocean Simulation Facility: 55,000-gallon tank with similar hydrostatic pressures equivalent to a depth of 2,250 feet
- Physiology lab where they conduct biomedical research and development
    - The facility can be used for contaminated water diving procedures and guidance as well human performance testing under thermal and hyperbaric conditions
- Experimental Diving Facility: 3 unmanned chambers

NEDU also conducts testing and evaluation for Authorized for Navy Use (ANU) listing. They make recommendations on equipment should and should be not be on the listing. Mr. Ferris provided two examples of testing and evaluation:

- Freezing water performance
    - Example: Investigation they conducted to understand the cause of three fatalities that occurred at the Aberdeen Proving Grounds
- Underwater breathing apparatus performance and capabilities
    - Example: Rebreather scrubbing CO_2
        - NEDU conducted studies to understand the duration a scrubber is effective with respect to temperature

He also highlighted the challenge of accounting for configuration management and stated that even small changes in equipment configuration should be tested for as it can impact performance. NEDU also conducts unmanned testing and evaluation to examine work of breathing and resistive effort as well as CO_2 retention with respect to a number of factors such as temperature, respiration rate, depth, humidity.

The NEDU also conducts manned testing and evaluation of equipment after the unmanned phase.

- Example: Contaminated water intrusion detection using fluorescein dye to differentiate between perspiration and water that is coming from outside the suit

NEDU conducts test and evaluation of specialized equipment for contaminated water diving including Category 1. From his perspective, he considers the best way to handle category 1 is through exhaust gas recovery, i.e., recovering the exhaust gas and piping it up to the surface. The

prototype system is surface-supplied with surface-exhaust. The prototype systems use the Kirby Morgan Diamond. He then highlighted challenges of pumping the exhaust gas back to the surface.

Finally, NEDU also conducts diving incident investigations, which includes both fatalities and near misses. Their focuses specifically on the equipment aspect of the investigation for issues such as incorrect assembly, improper maintenance, or equipment damage during a dive in order to understand how it may have contributed or not contributed to the event. They do this primarily for the military. They also have done this for other federal agencies and local enforcement, but NEDU has limited resources and time to manage and support these requests.

Discussion: None

4.1.3 Title: Bio ID: Real-time, portal pathogen detection system

Organization: United States Coast Guard (USCG)

Presenter: CWO Joe Erwin

Summary:

Based on discussions of potential available capabilities CWO Joe Erwin mentioned a detection unit the USCG is developing/using. At the request of participants, CWO Erwin provided a brief summary of this sensor's capabilities. The Bio-ID detection system was developed by the Lawrence Livermore National Laboratory (LLNL). The system is a portable pathogen detection system that can identify up to 18 pathogens in 30 minutes. Overall dimensions are 5" diameter x 3" height with a weight of 3 lbs. It is designed to be a one-step sample loading, isothermal heating, optical detection system, 2-year reagent stability, and USB/Bluetooth.

LLNL is currently working on assays for a number of biological targets. Currently Primary targeted assays it was developed for are biological warfare agents. Available assays include: (*E. coli, P. aeruginosa, S. typhimurium*) or under development *(A. hydrophila, L. pneuomphila, V. cholera, V. vulnificus, S. dysenteriae, K. pneumonia, L. monocytogenes, Hepatitis A, Hepatitis E, Enteroviruses, C. parvum, G. lambia, E. histolytica, I. belli, I. hominus*). CWO Erwin presented performance data from purified genomic DNA and presented data on direct detection of live pathogens.

Discussion: None

4.2 DAY 2 AFTERNOON SESSION, ROUNDTABLE REMARKS AND OTHER TOPICS OF INTEREST TO ATTENDEES

4.2.1 Roundtable Remarks

One of the goals of the workshop was to start engaging and forming partnerships with other organizations. Participants were given an opportunity to provide remarks on what they had learned, opportunities for collaboration, or on next steps.

CWO Joseph Erwin (USCG):

Stated that he would be happy to share information with members of the group. He stated that he would communicate and share information as it relates to contaminated water, provide who his relief will be as he transitions out of the USCG, and put individuals interested in the Bio ID device in touch with LLNL.

CDR Eric Johnson (NOAA):

Stated that that he will take the information back and discuss some of the information gathered at this meeting at one of their safety meetings.

LTJG Josh Fredrick (NOAA):

Stated that NOAA Tides and Currents has infrastructure for over 200-plus stations around the country and would be, as long as leadership agrees, willing to assist in installation or maintenance at those stations.

MDV Michael Sonnenberg (NECC):

Stated that they have validated requirements to help support the technology ONR is working towards. He stated that the requirement needs to be pushed up to bolster the technology from a Navy Expeditionary Combat Command viewpoint. As it relates to reporting and policy gaps, NAVSEA will drive that once current guidance is passed along.

Dr. Aaron Hall (NMRC):

Stated that he would take information gathered from this workshop and communicate with other researchers at NMRC to see if there are ways to support.

Dr. Paul Gillooly (NMCPHC):

Stated that NMCPHC could provide assistance in areas like industrial hygiene monitoring and potentially medical surveillance. He also stated that they are open to feedback on what they can do better to assist the warfighter. They have considerable assets on the epidemiological side and suggest that there may opportunities for synergy there. He plans on setting up a line communication with EPA as they move forward with their projects in Jubal Ali and Djibouti.

Dr. Art Chang (CDC):

Stated that they could offer National Institute for Occupational Safety and Health (NIOSH) and that they have a Maritime Safety and Health Studies. They also have the Agency for Toxic Substances and Disease Registry and the National Center for Environmental Health. They have conducted work in minimal risk levels, toxicity levels, how to do national surveillance, how to do community surveillance, modeling levels of concern and can provide assistance in those areas. In addition, they have laboratory capabilities for national bio monitoring studies and can measure most chemicals including heavy metals. Some data is only available to DoD and is also something that the

CDC can provide. CDC also oversees the National Syndromic Surveillance Program (NSSP), which examines all International Classification of Diseases-10 and ICD-9 codes on diagnosis and the DoD is one of data streams that uploads into the system. They can look at reported exposures of divers that present at medical facilities. In addition, they have partnership with National Poison Data System and can provide information if there are any cases in reported divers.

Mr. Sean Sheldrake (EPA):

Stated the EPA is happy to help how they can. They are willing to assist in terms of providing suggestions or ideas concerning decontamination solutions, protective equipment, immunizations they use, or their training regime. He offered that anyone could come and audit one of their training classes. He recommended that, as an organization, you need to focus on what your objectives are as far as protecting soldiers or employees, which will help determine thresholds and when to upgrade personal protective equipment. In regards to the GIS tool and if anyone wanted to put together a system for their own organization, he stated their GIS technician would be happy to discuss further.

Mr. Vince Ferris (NEDU):

He stated he was surprised to find out all the different federal agencies that dive. He stated that he is still interested in how this may apply to accident investigations and in being able to effectively test equipment that has been contaminated with pathogens without endangering personnel.

Ms. Jennifer Coughlin (USDR&E)

Stated that this was a valuable experience to have both operators and science and technology folks involved in order to understand what the problems actually are. She stated that she could help identify points of leverage outside of the Navy and outside of the diving community. For the environmental side, she may be able to identify points of contact with Army Corps of Engineers or within acquisition and sustainment at the highest level of their environmental programs. She suggested that, once problems are identified, to provide them to her so that she can pass them along to individuals within the Joint Environmental Programs or to individuals within Office of the Assistant Secretary of Defense for Environment to see if there are opportunities to leverage.

LT Reece Comer (EXWC):

Stated that once an e-mail distribution list is available, he can provide any reports or after-action reports. He also stated that if there is any research that required warfighter level support, their diver locker is unique in that it is made up of warfighters at shore duty operation location and to please reach out them if any support is needed.

EOCS Jim McVicar (EXWC):

Stated that he would reach out Navy Region Southwest and NMPHC to potentially collaborate on sampling and analysis. He stated that he can work on the grass roots level and disseminate any information gleaned from it through the Master Diver community.

Dr. Frauke Tillman (DAN):

Stated that DAN has a database that they can review for cases that have been discussed or for responses that they have seen. She recommended reaching out if there are DAN resources of interest.

Dr. Jim Chimiak (DAN):

Stated that this is one of the most difficult and complex topics in diving. He suggested a number of neat things to come out of the meeting were GIS tools, the need of medical surveillance, the idea of better PPE. He suggested that there are specialized dive groups that DAN can assist with to help understand health impacts due to contaminant exposure. He stated that, if there are different incidents of interest, please feel free to reach out to them. In addition, he offered that if anyone had any information to share, they could write an article for the DAN website.

CAPT Murphy (NAVSEA 00C3):

Stated that the most important piece of information is the contact list once it gets sent out to everyone. He stated he would be open to being a guest speaker for Sean Sheldrake's group at the EPA and would like to get one of the Master Divers to observe their training in order to take some of the EPA's best practices and procedures to help train and inform Navy divers and update the diving technical manuals.

He stated that there is some back and forth needed with NMPHC about developing a database, setting up funding steam, and assisting NMPHC putting up proposals in the areas of contaminated water diving. He suggested that NMPHC may want to leverage how the EPA sets up their database.

Dr. Sandra Chapman (ONR):

Stated that she sees lots of ways that she can partner with NIH, CDC, and DTRA to start figuring out the thresholds from a health and medical perspective. She stated that much of this will rely on technology for collecting data on the current state of the water and will be an inherent aspect that she will not ignore. She stated that one avenue to help further collaboration is using the CRUD site on APAN.

Dr. Rob George (NIWC Pacific):

Stated that he was very appreciative of everyone's participation and we are in the process of finalizing a document that we can share with group. He also stated that it would be helpful to prioritize what was discussed into short- and long-term targets.

Dr. Patrick Sims (NIWC Pacific):

Stated that NIWC Pacific would be working on incorporating everything discussed during the meeting into the risk-based framework form and that he may be able to incorporate the LLNL BIO-ID device in ongoing work assessing and optimizing real-time or near real-time biological detectors for use in the marine environment.

4.2.2 OTHER TOPICS OF INTEREST

Similar to the first day, the dialogue from the morning and afternoon sessions evolved into a more organic, free-flowing discussion. While some of these discussion topics occurred earlier in the day, they have been consolidated here as other key priority gaps not identified on day one and/or other topics of interest to the workshop attendees.

Environmental Data Collection

One participant stated he would like to test all the major shipyards, i.e., Pearl Harbor, Norfolk, Bremerton, and San Diego. Building on this, CAPT Murphy states in CONUS there are sources that can provide the sampling and testing, but the other important piece that we need to look at is being able to test sites or locations that do not have the infrastructure support.

A participant from NOAA suggested that it may be worth looking into attaching a sensor or water or sediment collector to their already existing water stations are all over the country.

Another participant suggested reaching out to US Army Corps of Engineers (USACE) as they may have already been collecting data on water or sediments at relevant sites. Another agreed with this and stated that you have to search for the data, as the USACE is not necessarily transmitting or notifying divers of their findings. One would need to call up USACE district office.

Lead Exposure Scenario

EOCS McVicar brought up the point that divers are not monitored for lead exposure. He stated that they are handling soft weight pouches and are being exposed to colloidal lead. Sean Sheldrake suggests that an Industrial Hygienist would be able to assist in measuring potentially quantifying the exposure. In response to this, Dr. Gillooly stated that he had done some site surveys at dive lockers and this has not been brought to his attention previously. EOCS McVicar stated the divers know about it, but that no one says anything. Dr. Gillooly suggested that there are ways to see if this exposure is a problem, and suggested they can work on that if it is something the divers would like to pursue.

EOCS McVicar offered to reach out to San Diego office and have them test for lead.

Biomonitoring Test

One of the physicians discussed the difficulties in conducting biomonitoring testing for exposure to contaminants. He stated that tests are normally not sensitive enough and that a diver would need major exposure to the contaminant (e.g., like for arsenic), in order for it show up in blood or urine.

Another physician commented that some contaminants are better monitored from certain sources. For example, inorganic mercury needs to be collected from urine within 24 hours. He further suggested that it is critical to have a specialist review results to decide if a positive test for arsenic or mercury, for example, is based on diver exposure or something else.

Ocean and Untreated Recreational Water Resources

Michelle Hlavsa states that she can provide a list of outbreak information compiled by the CDC for ocean or lakes of untreated recreational water.

Priority Gap: Medical Surveillance and Reporting

Duration: Short and Long term

Potential Solutions:

- Conducting industrial assessment of dive locker
- Ensuring that the right information is being captured and recorded in dive reports and SF-600 as this has implications for the present and future
    - Currently Dive Jump Reporting System has check box for contamination and 150 characters describe it
    - There is no guidance or training on what should be entered in regards to contamination
    - As there currently is no way to know for certain what they were diving into, at what concentration, or if they were exposed, one can only make assumptions that they may have been exposed
    - May need a culture shift in documenting contaminated water dives and in identifying what constitutes contaminated water, e.g., harbor with loading dock may be considered contaminated
    - Contamination box might only be checked if it is visibly or grossly contaminated, e.g., odor, oil sheen, dead animals, sewage
    - Once/if database is established, it may be as simple as referencing GIS coordinate to determine if water is contaminated
- Ensuring that pre-deployment and post-deployment health risk assessments are conducted with accurate reporting
- Ensure diver and Unit Medical Officer (UMO) connectivity
- Opportunities for technologies that provide physiological monitoring in order to take burden off of self-reporting and provide insight on state of diver during dive

Additional Environmental Intelligence Gap

- Secondary Gap: Technology capabilities that provide awareness of agents and contaminants of concerns that should be monitored

Administration of Prophylactics—Potential Gap

- Prophylactics may be prudent if diving in contaminated waters (e.g., diving in areas with sewage discharges)
- Example: No prophylactics were provided to divers out in Micronesia even though sewage was being discharged into the water.

WORKSHOP POINTS OF CONTACT

For general questions regarding information included in these proceedings, as well as information on how to become a member of the CRUD Stakeholder working group and/or gain access to the CRUD Stakeholder share site please contact:

Dr. Kara C Sorensen

Environmental Sciences Branch, Code 71750

Naval Information Warfare Center Pacific (NIWC Pacific) Phone:

619-553-1340

Email: sorensek@spawar.navy.mil; kara.c.sorensen.civ@us.navy.mil

For information regarding the CRUD workshop, ongoing research initiatives related to this topic, and/or ONR's Undersea Medicine Program please contact:

Dr. Sandra Chapman

Program Officer, Undersea Medicine

Warfighter Protection and Applications Division Office of Naval Research

Phone: 703-588-2429

Email: sandra.e.chapman2.civ@us.navy.mil

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REFERENCES

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4. DoD Instruction 6490.03, “Implementation and Application of Joint Medical Surveillance for Deployment.
5. Contaminated Water Diving: Effects Criteria, Categorization, and Tools for Pre-Dive Assessment, Kara Sorensen, Ron Gauthier, Y. Meriah Arias-Thode, Environmental Sciences Branch, SPAWAR Systems Center Pacific.
6. Diving in contaminated water: Health Risk Matrix. Bernadette Quémerais, Defence R&D Canada – Toronto Technical Report 2006-126.
7. U.S. Navy [2019] Guidance for Diving in Contaminated Waters. Technical Manual #SS521-AJ-PRO-010. Naval Sea Systems Command, Washington Navy Yard, Washington, D.C., Oct 2019.
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APPENDIX A
CRUD STAKEHOLDER PARTICIPANT PRESENTATIONS

Description – these appendices include the presentation slides from each presenter during the first two days of the workshop. The version of slides included in this document were approved by each presenter for "public release" prior to inclusion in this report.

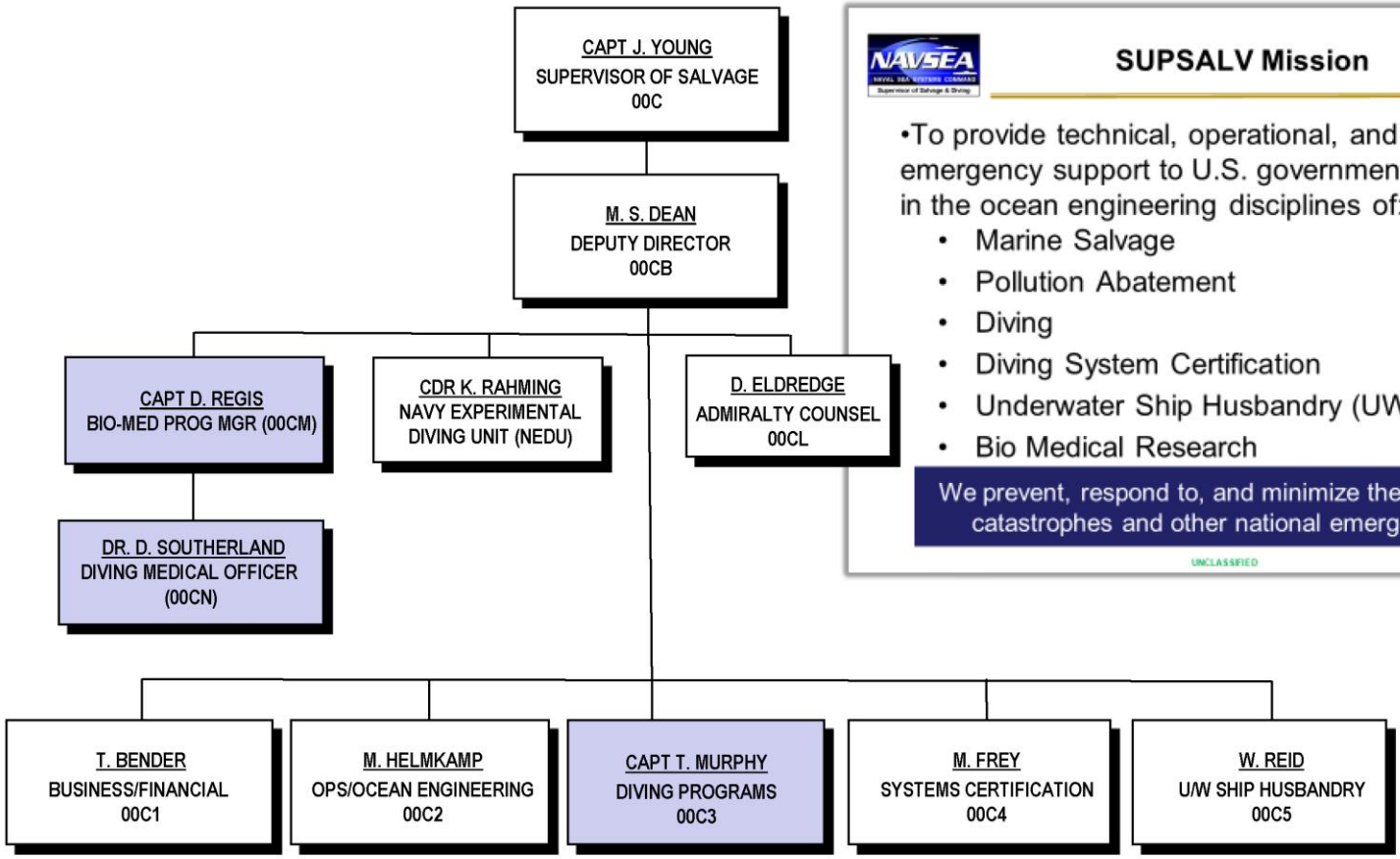
NAVSEA 00C3
Contaminated Water Diving

Office of Naval Research (ONR)
Contamination Risk for Underwater Divers (CRUD) Workshop 2020
05 - 06 March 2020

Presented by:
CAPT Thomas Murphy, US Navy Supervisor of Diving
thomas.p.murphy3@navy.mil

Overall Classification:
UNCLASSIFIED

SUPSALV Leadership Organization



SUPSALV Mission

- To provide technical, operational, and emergency support to U.S. government agencies in the ocean engineering disciplines of:
  - Marine Salvage
  - Pollution Abatement
  - Diving
  - Diving System Certification
  - Underwater Ship Husbandry (UWSH)
  - Bio Medical Research

We prevent, respond to, and minimize the effects of catastrophes and other national emergencies.

UNCLASSIFIED 2

UNCLASSIFIED

2

Guidance for Diving in Contaminated Water

OPERATIONAL NEED

Objective: Provide guidance for Fleet activities conducting contaminated water diving operations in order to provide maximum protection consistent with the contamination threat.

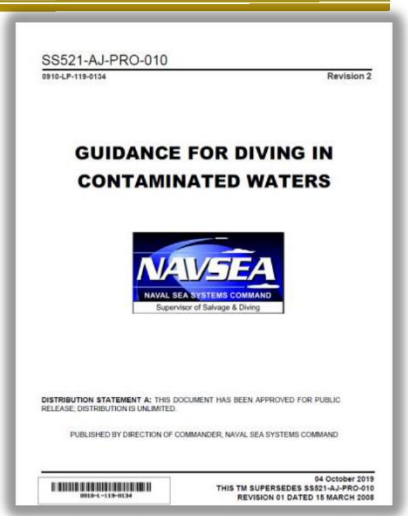
- Revision 2 published 04 October 2019.

The Technical Manual provides:

- Definitions of contaminants and hazards
- Equipment considerations
- Pre-dive planning considerations
- Decontamination procedures / SOPs
- Information sources / links
- NAVSEA decontamination equipment inventory

The Technical Manual does not:

- Identify biological contaminates of concern
  - CONTAMINATED WATER DIVING: EFFECTS CRITERIA Kara Sorensen, PHD SPAWARS AUG 2009
- Incorporate contaminates of concern into established contaminated water categories (CAT 4 – 1)
  - Baseline contaminated
  - Moderately contaminated
  - Heavily contaminated
  - Grossly contaminated
- Provide a standardized risk management decision making aid based on quantifiable metrics


SS521-AJ-PRO-010
Revision 2

GUIDANCE FOR DIVING IN CONTAMINATED WATERS

NAVSEA
NAVAL SEA SYSTEMS COMMAND
Supervisor of Salvage & Diving

DISTRIBUTION STATEMENT A: THIS DOCUMENT HAS BEEN APPROVED FOR PUBLIC RELEASE; DISTRIBUTION IS UNLIMITED.

PUBLISHED BY DIRECTION OF COMMANDER, NAVAL SEA SYSTEMS COMMAND

04 October 2019
THIS TM SUPERSEDES SS521-AJ-PRO-010 REVISION 01 DATED 15 MARCH 2008

https://www.navsea.navy.mil/Home/SUPSALV/00C3-Diving/Contaminated-Water-Diving/

TABLE 2-1. CONTAMINATED WATER CATEGORIES AND DEFINITIONS.

Contaminated Water Categories (CAT)	Definitions
CAT 1	a. Grossly contaminated b. Extreme Risk of Injury or even Death (Note 1) c. Fully Encapsulated Diver with Surface Return Exhaust or Positive Pressure Free-Flow Helmet (Note 2) (Note 3)
CAT 2	a. Heavily contaminated b. High Risk of Injury (Note 4) c. Fully encapsulated Diver (Note 2) (Note 3)
CAT 3	a. Moderately contaminated b. Some risk of Injury especially if Ingested c. Full Face Mask (FFM) and Skin Covered as necessary (Note 5)
CAT 4	a. Baseline contamination (Note 6) b. Low risk of Injury (Note 7) c. Standard diving dress based on environmental conditions

UNCLASSIFIED

Port Contamination Example

Objective: Provide port force protection and ship maintenance dive support

Operational conditions:

- Desert
- Climate: Jun-Sep (110°F) / Oct–May (96°-75°F)
- Water temperatures: 95°-70°F

Contaminated water conditions:

- Fluctuation in inner harbor water conditions monthly
  - Purple water
  - Strong odor
  - Equipment corrosion

Actions / concerns:

- Conditions based on visual observations
- Implement mitigation measures
- Determination: safe to assume normal operations
- Tests are time dependent / inefficient; funding required

Normal Water Color

Contaminated Water Color

UNCLASSIFIED

Conshelf XIV SCUBA Regulator

Pre-Dive Condition

Post-Dive Condition

Port Contamination Example

Objective: Provide port force protection diving support

Operational conditions:

- Tropical desert
- Climate: 78-97° F
- Water temperature: 79-89°F

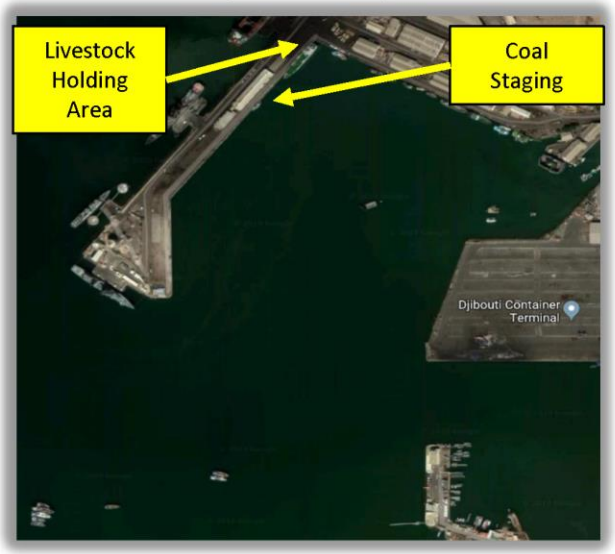
Contaminated Water Conditions:

- Multiple conditions / varying pier activity
  - Fuel oil
  - Live stock waste
  - Coal runoff

Actions / Concerns:

- Conditions based on visual observations
- Implement mitigation measures
- Determination: safe to assume normal operations
- Tests are time dependent / inefficient; funding required

Port Facility



48 hrs post-dive

96 hrs post-dive

120 hrs post-dive

UNCLASSIFIED

Ship Salvage Contamination Example

Objective: Provide in water damage repair for ship support / recovery

Operational conditions:

- Tropical
- Climate: 86-90° F
- Water temperature: 85°F

Contaminated Water Conditions:

- Multiple conditions
  - Fuel oil/ JP5
  - Black and grey water
  - Human remains

Actions / Concerns:

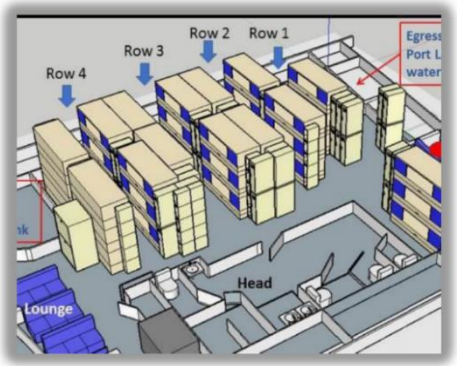
- Conditions based on visual observations
- Implement mitigation measures
- Immediate Decontamination site on dive side
- Medical observance and monitoring
- Limited bottom time / exposure due water temp and diver physiological concerns (< 4 hrs per day)

Fuel oil in the water

Berthing 5 after salvage

Berthing 3 above water level

Berthing 5 orientation



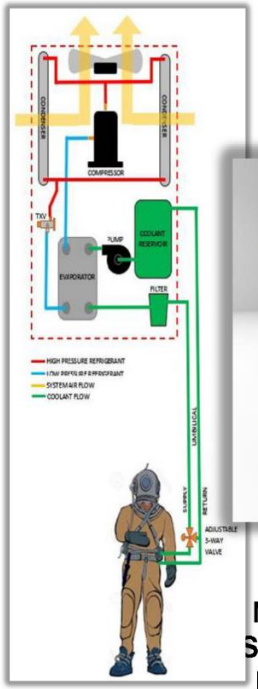
Navy CWD Capability Gaps

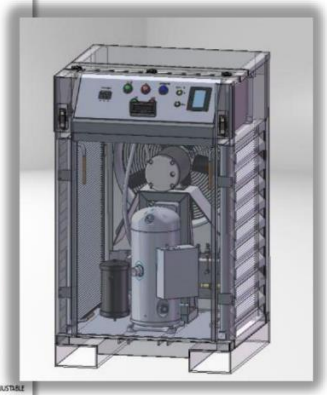
- No definitive list of contaminates and go / no go criteria
- No CAT 1 diving capability; lack of approved equipment
- No ability to continuously maintain diver comfort through the entire range of diving capability temperatures in a contaminated environment
- No standardized / responsive test program

Kirby Morgan Diamond Helmet

CRYE Full Encapsulation Contaminated Water

Heavy Duty Vulcanized Rubber Drysuit





NAVY Surface Supplied Diving Heater/Chiller Assembly

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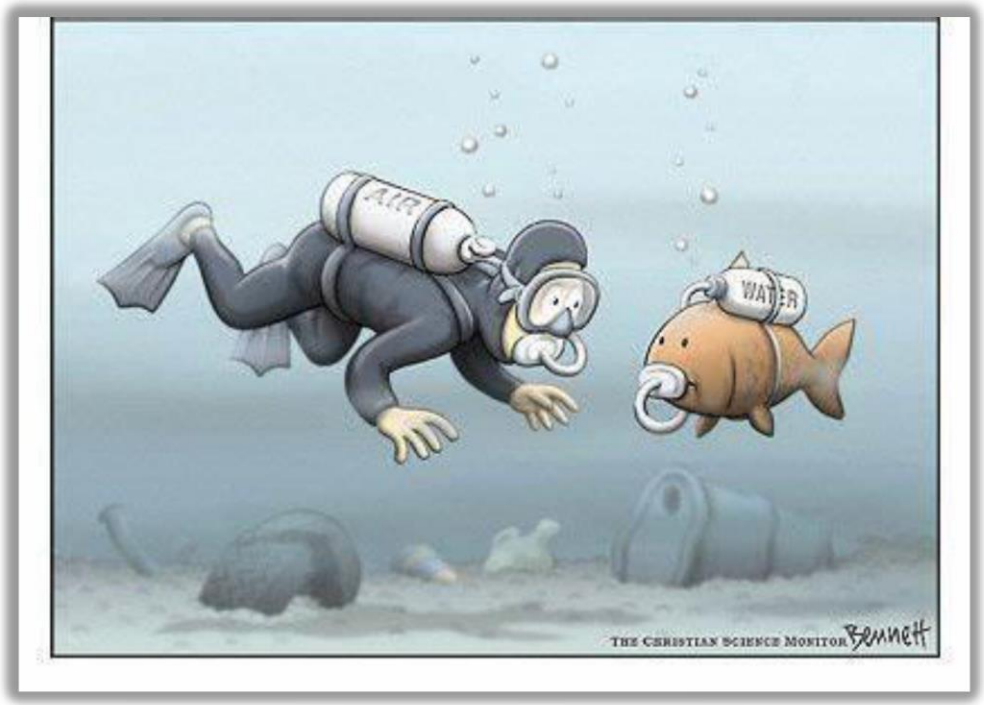
Questions



Bennett Cartoon Archive: Water Pollution

https://www.bing.com/images/search?view=detailV2&id=4D34093269C832DF4BF301C0D007D3ACA6440B92&thid=OIP.kplTgned9yiSsIL3Uaf08wAAAA&mediaurl=https%3A%2F%2Fs-media-cache-ak0.pinimg.com%2Foriginals%2F65%2Fe8%2F0f%2F65e80f5ffd534394796e46b495f0e230.jpg&exph=300&expw=423&q=contaminated+water+diving+picture&selectedindex=191&ajaxhist=0&vt=0&eim=1,2,6

Chemical Contaminants of Concern

Table 1: Combined ECs for Common COCs

Chemical Name	Primary Exposure Risk *(Ranked highest-lowest)*	Classification *(Ir=Irritant, V=Volatile, Car=Carcinogenic, Tox=Acutely Toxic)*	Acute, Combined Pathways	Sub Chronic, Combined Pathways	Reference*
ORGANICS			ug/L	ug/L	
Acrolein	Inhalation-absorption-ingestion	Ir, V	5.4E+05	2.3E+05	HSDB-CASRN: 107-02-8
Acrylonitrile	Inhalation-absorption-ingestion	Tox, Car, V, Ir to Skin	1.8E+04	2.2E+03	HSDB-CASRN: 107-13-1
Benzene	Absorption-inhalation-ingestion	Car, V	3.2E+04	4.6E+03	HSDB-CASRN: 71-43-2
Creosote	Inhalation-absorption-ingestion	Car, Ir	TBD	TBD	HSDB-CASRN: 8001-58-9 Cool Tar
Chlorosulfonic Acid	Inhalation-absorption	Ir, Tox	NA	NA	HSDB-CASRN: 7790-94-5
Ethylene Glycol	Absorption-ingestion-inhalation	Ir, Tox	1.4E+08	5.8E+07	HSDB-CASRN: 107-21-1
PCBs	Inhalation-absorption-ingestion	Car, Tox	2.0E+01	2.9E+00	HSDB-CASRN: 1336-36-3
Phosphoric Acid	Inhalation-inhalation-absorption	Ir, Tox	NA	NA	HSDB-CASRN: 7664-38-2
Phenol	Ingestion-absorption-inhalation	Ir	6.3E+07	1.6E+07	HSDB-CASRN: 108-95-2
Styrene	Ingestion-inhalation-absorption	Tox, Ir	1.1E+06	9.4E+05	HSDB-CASRN: 100-42-5
Sulfuric Acid	Inhalation-Ingestion	Ir, Tox	NA	NA	HSDB-CASRN: 7664-93-9
Toluene	Ingestion-inhalation	V	1.0E+07	1.2E+05	HSDB-CASRN: 108-88-3
Vinyl acetate	Inhalation-ingestion-absorption	V	1.7E+08	7.3E+07	HSDB-CASRN: 108-05-4
Xylene	Inhalation-ingestion-absorption	V	7.9E+06	1.4E+06	HSDB-CASRN: 1330-20-7
METALS					
Chromium (Total)	Ingestion-inhalation	Car, Tox	NA	NA	HSDB-CASRN: 7440-47-3
Chromium (+6, Hexavalent)			1.1E+05	4.6E+04	
Cadmium	Ingestion-inhalation	Car, Tox	5.2E+03	2.2E+03	HSDB-CASRN: 7440-43-9
Lead	Ingestion-Inhalation	Ir, Tox	NA	NA	HSDB-CASRN: 7439-92-1
Arsenic	Ingestion-Inhalation	Car	5.4E+03	7.7E+02	HSDB-CASRN: 7440-38-2
Mercury	Ingestion-inhalation-absorption	Ir, Tox	1.8E+05	3.3E+04	HSDB-CASRN: 7439-97-6
Selenium	Ingestion-Inhalation	Ir, Tox	3.7E+05	1.6E+05	HSDB-CASRN: 7782-49-2
Zinc	Ingestion-inhalation-absorption	Ir, Tox	4.1E+07	1.8E+07	HSDB-CASRN: 7440-66-6

(*) References are assocated with chemical information and not EC number. EC's are based on conversion of RfD

CONTAMINATION RISKS ASSOCIATED WITH DIVING

State of Science

Drs. Kara C. Sorensen*, Rob George & Patrick Sims
NIWC Pacific

ONR Undersea Medicine Program
CRUD Workshop

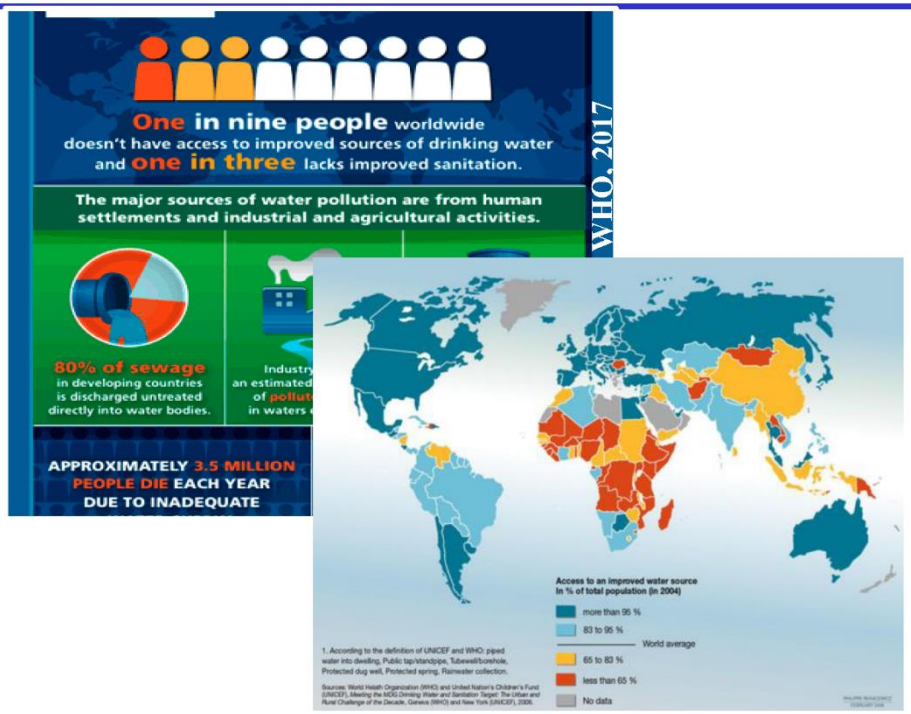
5 March 2020

Outline

- Water Pollution Global Issue
  - Domestic and DoD context
- Contaminated Water Diving (CWD) Response Paradigm
  - Pre-dive assessment current methods
  - Current and past focus
- CRUD WORKSHOP OBJECTIVES

Water Pollution

Global Issue



Most waterbodies contain some level of contaminant (biologic or chemical)

Forward operation sites located in **Latin America**, **Asia**, & **Africa** pose the greatest risk of exposure.

- ~70% of their water resources receiving an impaired/ poor* condition (UNEP, 2016)
- However, probability of exposure to some level of (COC)^ in developed countries is still high

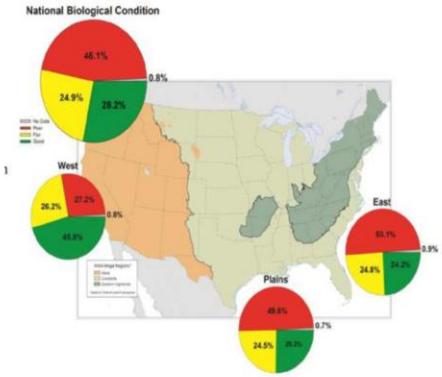
*** Unable to support one or more designated uses; ^ contaminant of concern**

Water Pollution

Domestic and DoD Context

Naval Information Warfare Center PACIFIC

National Water Quality Index



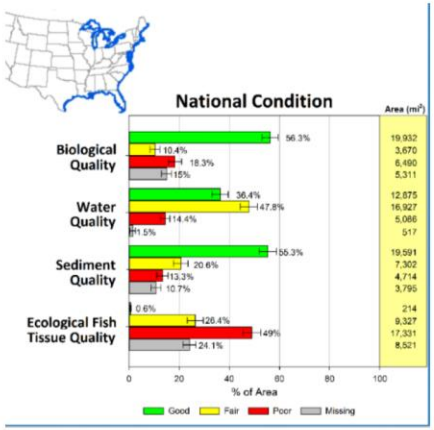


Figure 1. Biological condition of the nation's rivers and streams (Source: NRSA 2008/09)

(*Figures from NCCA 2010 report)*

- 43% of US water resources are listed as impaired (unable to support at least one of their designated uses).*
- Coastal water estuaries, embayment, great lakes and shore lines highest level of impaired sites (78-81%)*
  - Waterbodies frequented by divers for routine operations

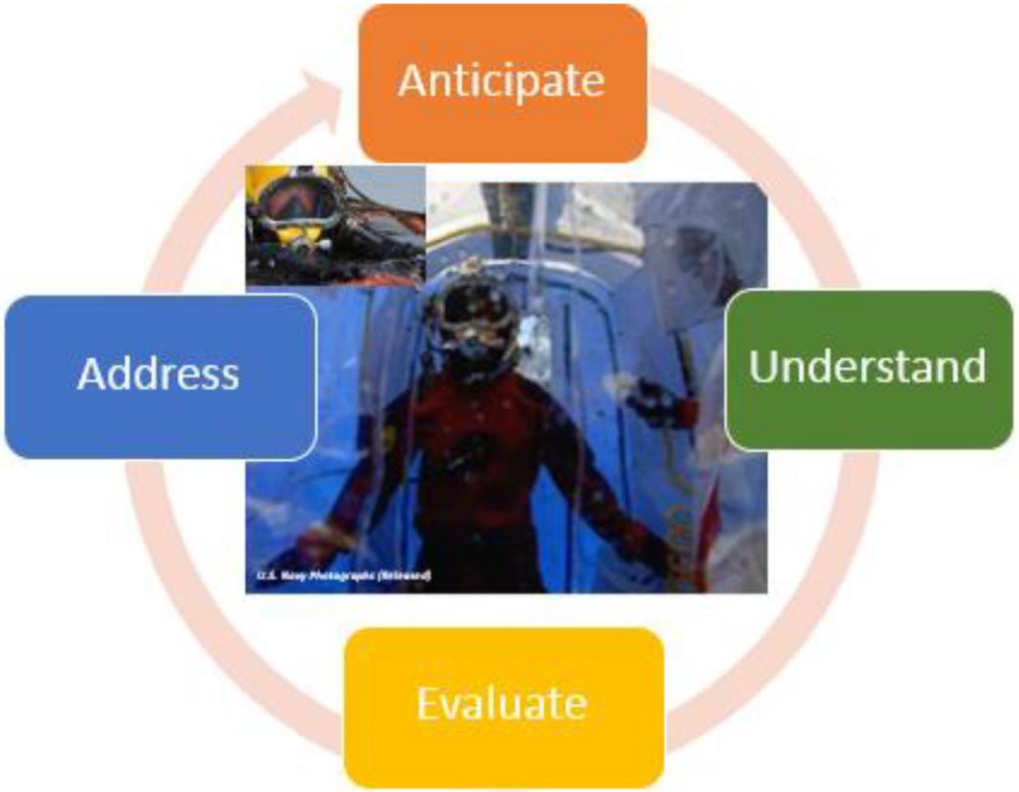
*US EPA (2017)

DOD Context

- **Health and safety risk**
- Various missions rely on quality of water to perform functions

But these concerns are not unique to the DOD

CWD Response Paradigm



Pre-Dive Assessment

Current Process By Dive Supervisor

Assess Available Information

Any Quantitative info?
- Local WQ offices
- Recent environmental studies
- Local environmental regulation agencies

Any additional factors to consider?
- Intrinsic behavior of COC
- Urgency of dive ops
- Current /Recent environmental conditions (e.g. recent rain, points of discharge, working in sediment, biologic remains)
- Type of water body diving in
- Available PPE

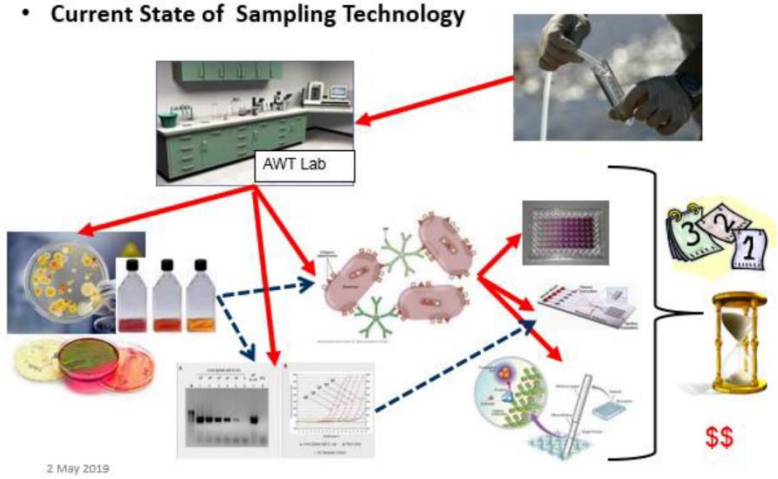
Any specific COC suspected?
- Determine any onsite evaluation tools (i.e. metals/PAHs).
- Identify Laboratory for analysis/ type of sample required (e.g. biologics)?
- Collect sample and analyze

Dive Category?
- Cat 1: Grossly contaminated (extreme risk/injury possible)
- Cat 2: Heavily contaminated (high risk)
- Cat 3: Moderate contamination (some risk)
- Cat 4: Baseline contamination

Collect Additional Information

Factors Consider w/Laboratory Analysis

- **Current State of Sampling Technology**



Paradigm

Recent Focus

Naval Information Warfare Center PACIFIC

Protective Equipment

Anticipate

Address

Understand

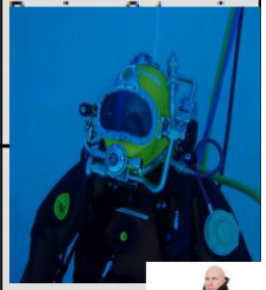
Contaminant Detection

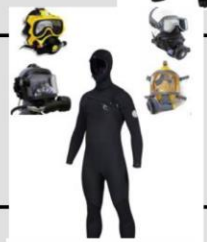
Evaluate

Address

Personnel Protective Equipment

Contaminated Water Categories (CAT)	Definitions	Comments
CAT 1	a. Grossly contaminated b. Extreme Risk of Injury or even Death (Note 1) c. Fully Encapsulated Diver with Surface Return Exhaust or Positive Pressure Free-Flow Helmet (Note 2) (Note 3)	(No diving systems on ANU* list meets CAT 1 protection requirements)
CAT 2	a. Heavily contaminated b. High Risk of Injury (Note 4) c. Fully encapsulated Diver (Note 2) (Note 3)	In-water-exhaust helmet and drysuit
CAT 3	a. Moderately contaminated b. Some risk of Injury especially if Ingested c. Full Face Mask (FFM) and Skin Covered as necessary (Note 5)	Full face mask and wetsuit
CAT 4	a. Baseline contamination (Note 6) b. Low risk of Injury (Note 7) c. Standard diving dress based on environmental conditions	Standard mask





*Thanks to Vince Ferris (NEDU) for slide content

Evaluate

COC Detection Capabilities

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COTS (Chemical)

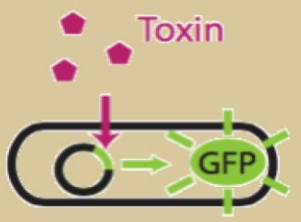
- **Mass Spectroscopy**
  - FLIR Griffin
  - MT Explorer 50
- **Ion Mobility Spectrometry**
  - Draper microAnalyzer
  - Bruker RAID
- **Optical**
  - Bruker BRAVO
  - Rigaku Progeny

COTS (Biological)

- **Nucleic Acid-Based**
  - Biomeme Franklin
  - T-COR 8
- **Immunoassay**
  - NIDS Biothreat Detection System
  - PathSensors Zephyr

Future

- **Field-deployable Sequencing**
  - MinION Sequencer
- **Omics**
- **Synthetic Biology-Based**



Paradigm

Future Focus

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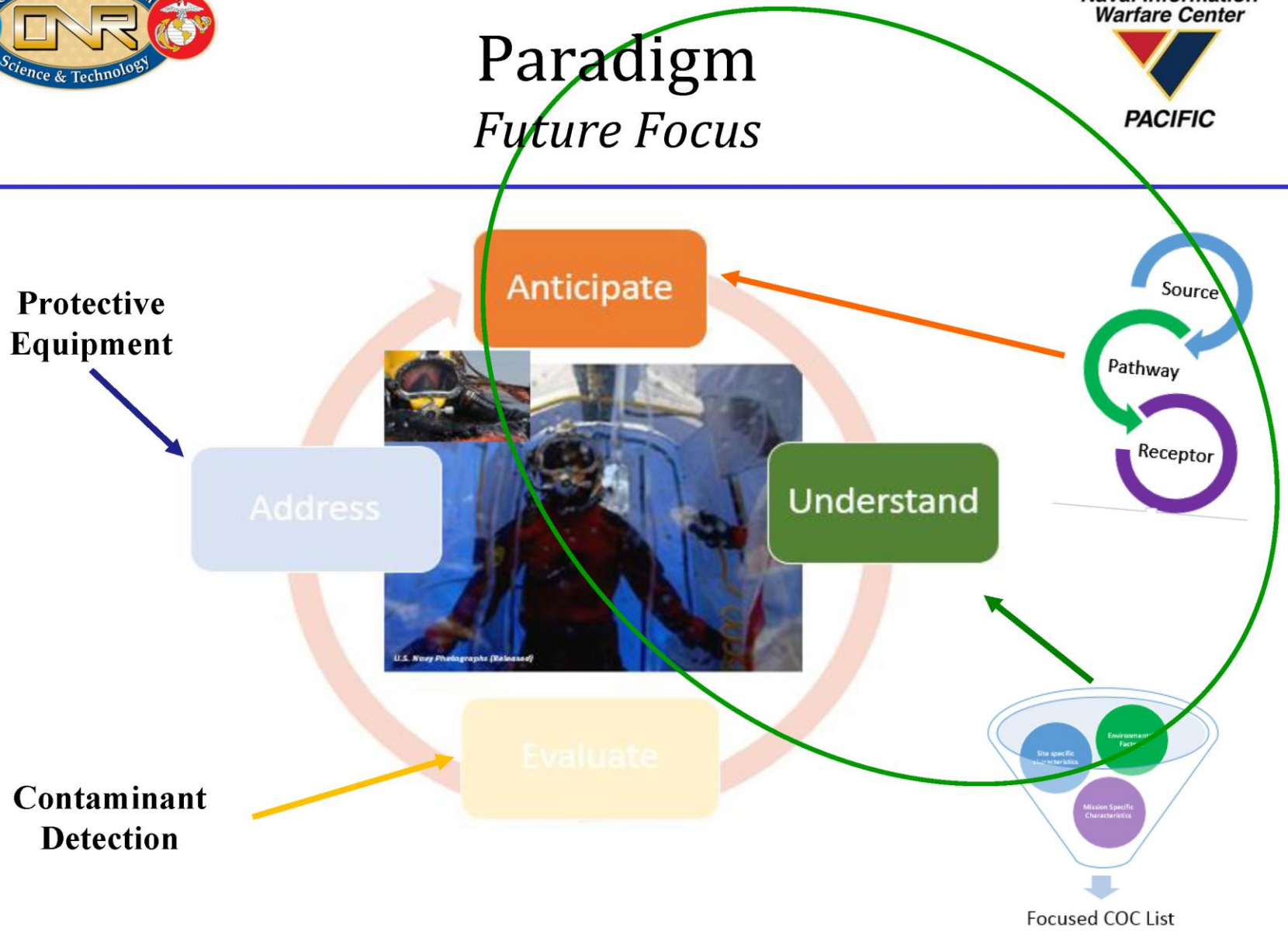
Protective Equipment

Contaminant Detection



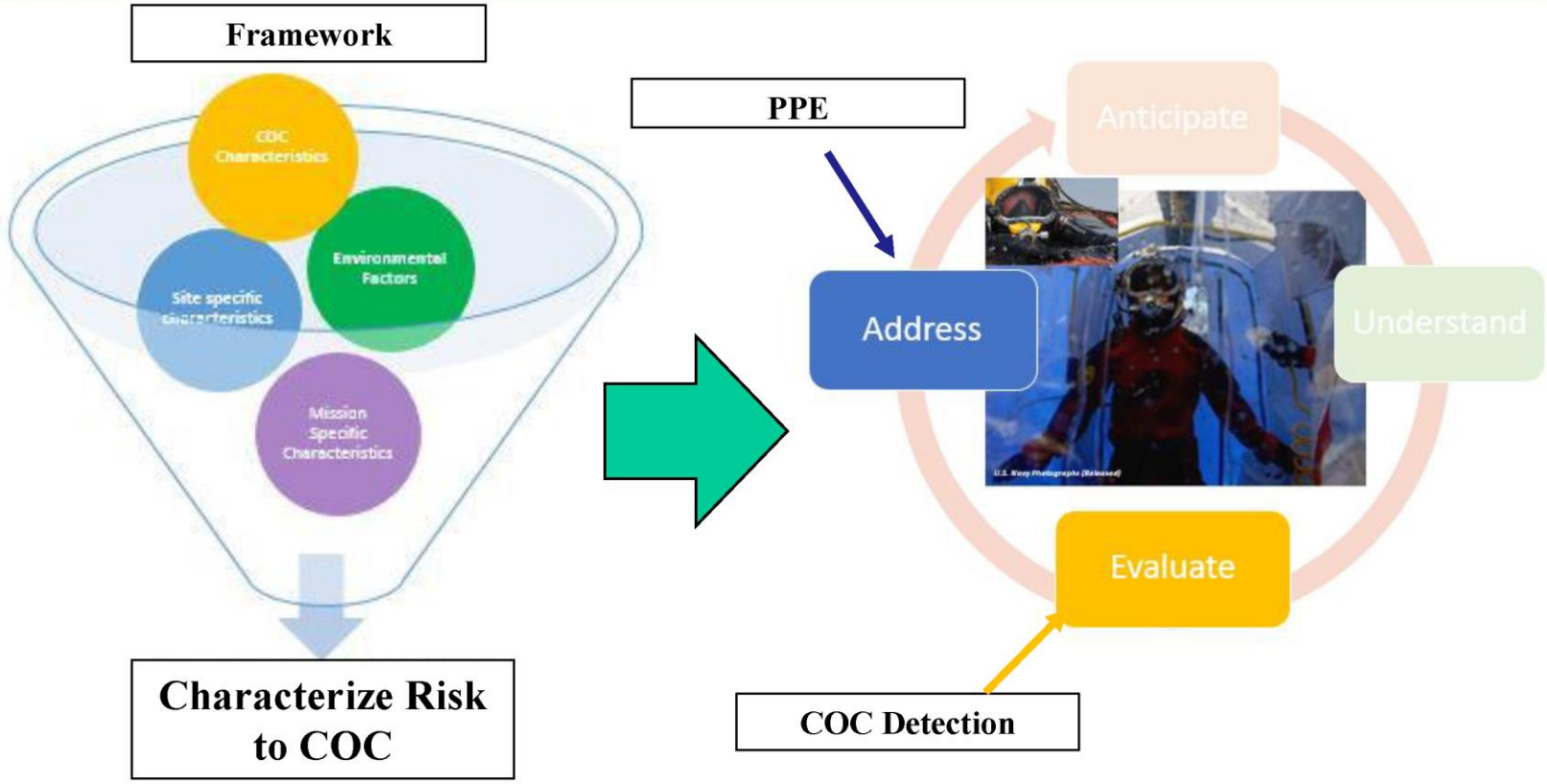
How Do we Better Anticipate and Understand the problem?

- Develop guidance for addressing data gaps that impact how to broadly evaluate CWD site characteristics and potential risk to divers

Approach:

  - Consider legacy pollutant vs. current and future site conditions
  - Understand how to address site specific or emergent COCs
  - Enable dive scenarios to be defined by site specific characteristics
  - Provide platform (Workshop) for key stake holders to collaborate and communicate
  - Define Data Gaps and a risk characterization framework
  - Build on prior workshops, guidance documents, publications, etc.

Technical Approach
Framework Applied



Provide a platform of discussion and collaboration focused on mitigating potential adverse health effects related to diving in contaminated waters

CRUD
Workshop

Naval Information Warfare Center PACIFIC

Goal:

1. To better understand past, present, and future initiatives related to environmental water quality contaminants, safe exposure limits, and environmental scenarios.

2. Develop solutions for addressing CWD issues that are scientifically based, realistically achievable, and designed to protect diving personnel.

Objectives

1. Define global risk characteristics
2. Obtain consensus
3. Develop solutions or requirements
4. Define mitigation path for potential adverse health effects related to diving in contaminated waters.
5. Identify key near-term and long-term capability gaps
6. Foster communication between stakeholders

Planned Focus

Day 1

- Define Risk Characterization framework
- Understand Multi Agency Perspective
- Explore global risk characterization perspective
  - Consequence Exposure
  - COC Determination,
  - Exposure Determination
  - Likihood of exposure

Day 2

- Define Risk Boundaries
  - Prioritize
  - Come to consensus
- Identify Data Gaps
  - Global perspective
  - Organization specific perspective
- Determine Future Directions

BACKUPS →

Contamination Risk for Underwater Divers (CRUD) Workshop

Location: 4401 North Fairfax Drive Suite 321 Arlington, VA 22203

March 5th and 6th, 2020

Contaminated Water Diving Risk Characterization Framework

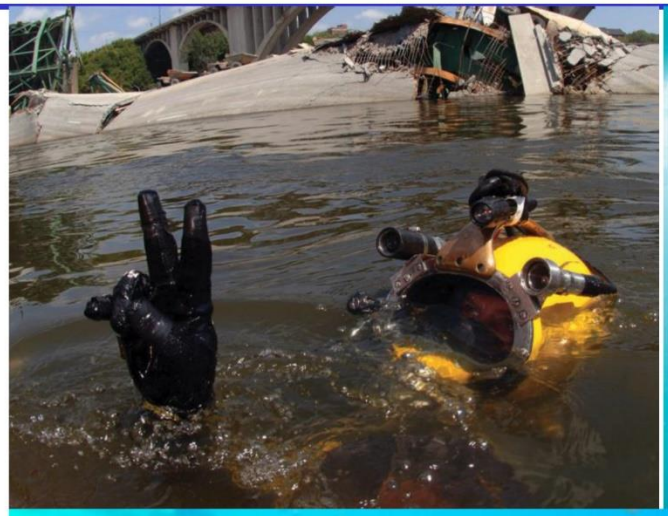
Dr. Kara Sorensen
Dr. Patrick Sims
Dr. Rob George

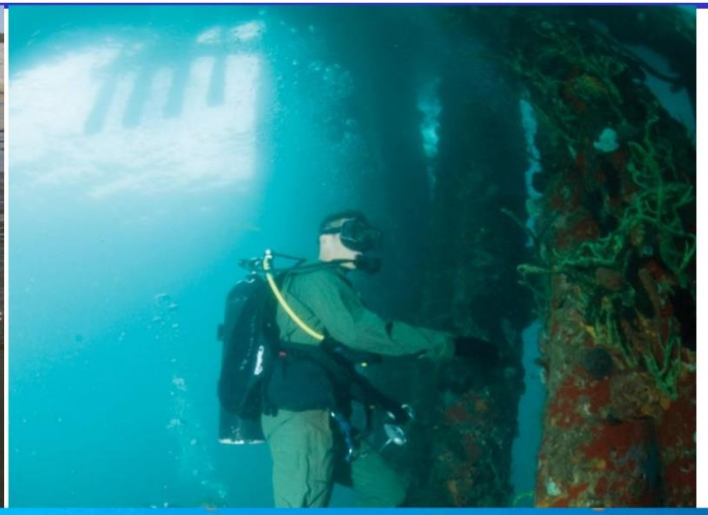
Naval Information Warfare Center (NIWC) Pacific

Prepared for: ONR Undersea Medicine Program

Arlington, VA 05-06 March 2020

Risk? What Risk?





Workshop Goal Statement

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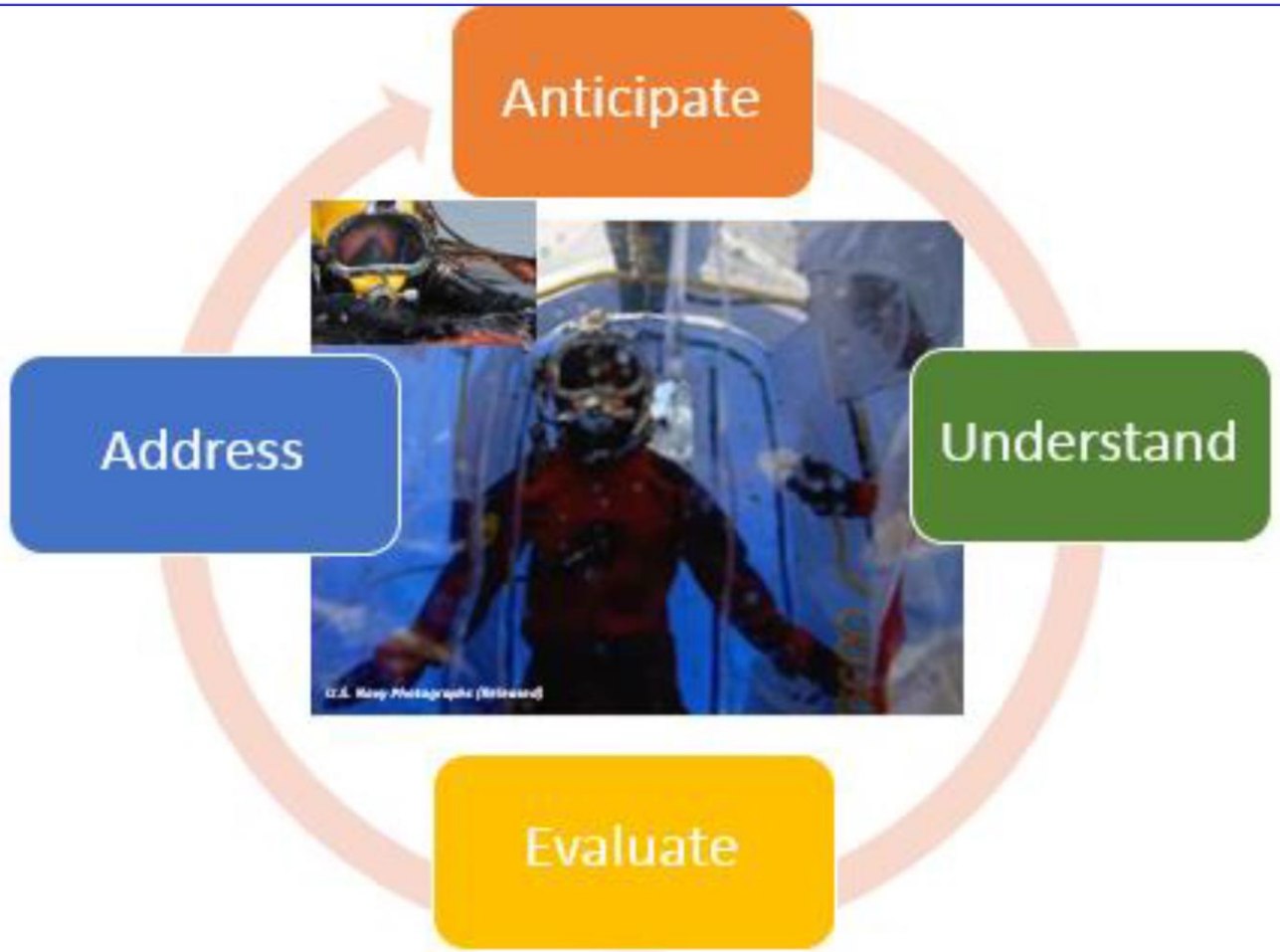
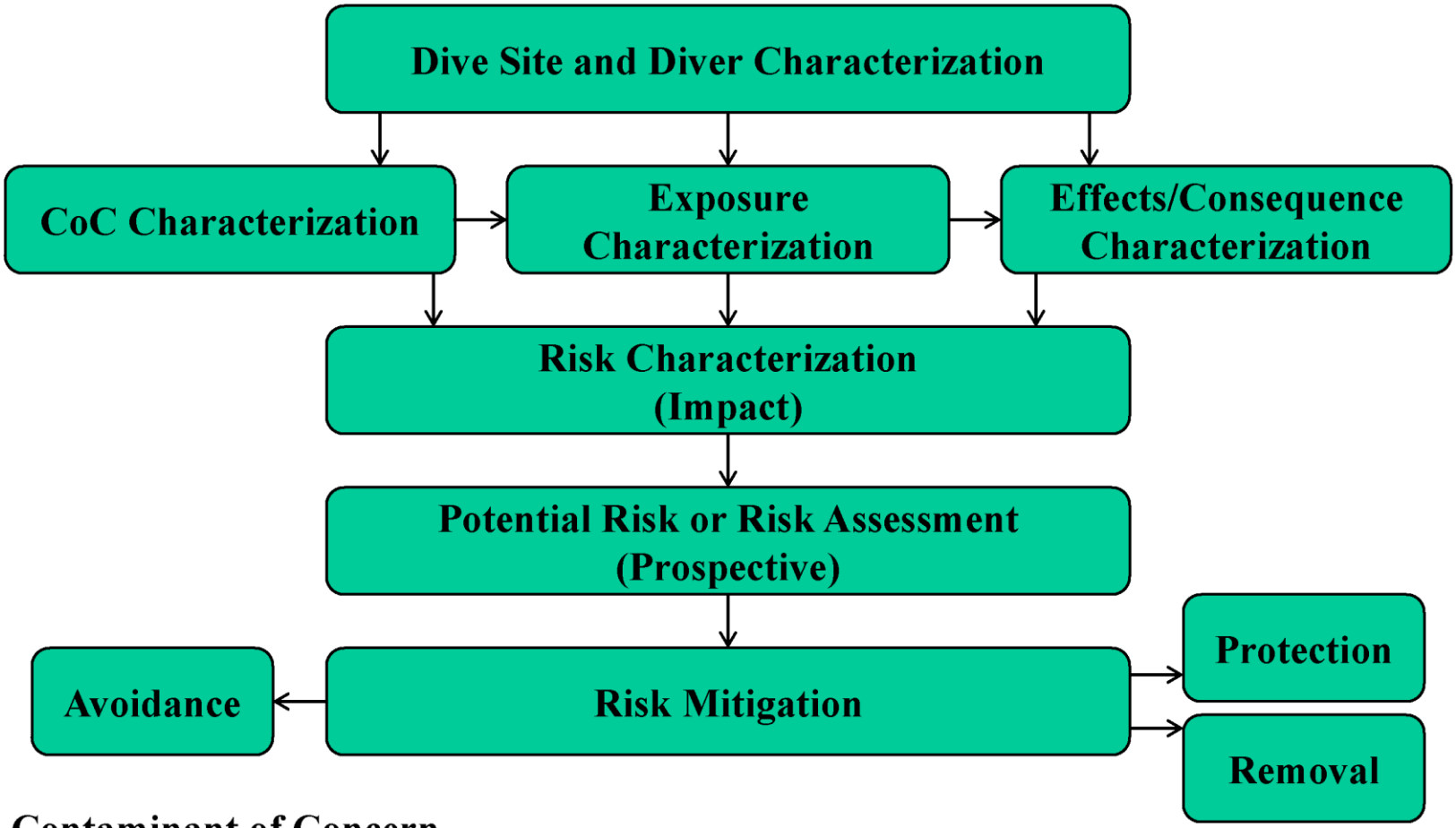
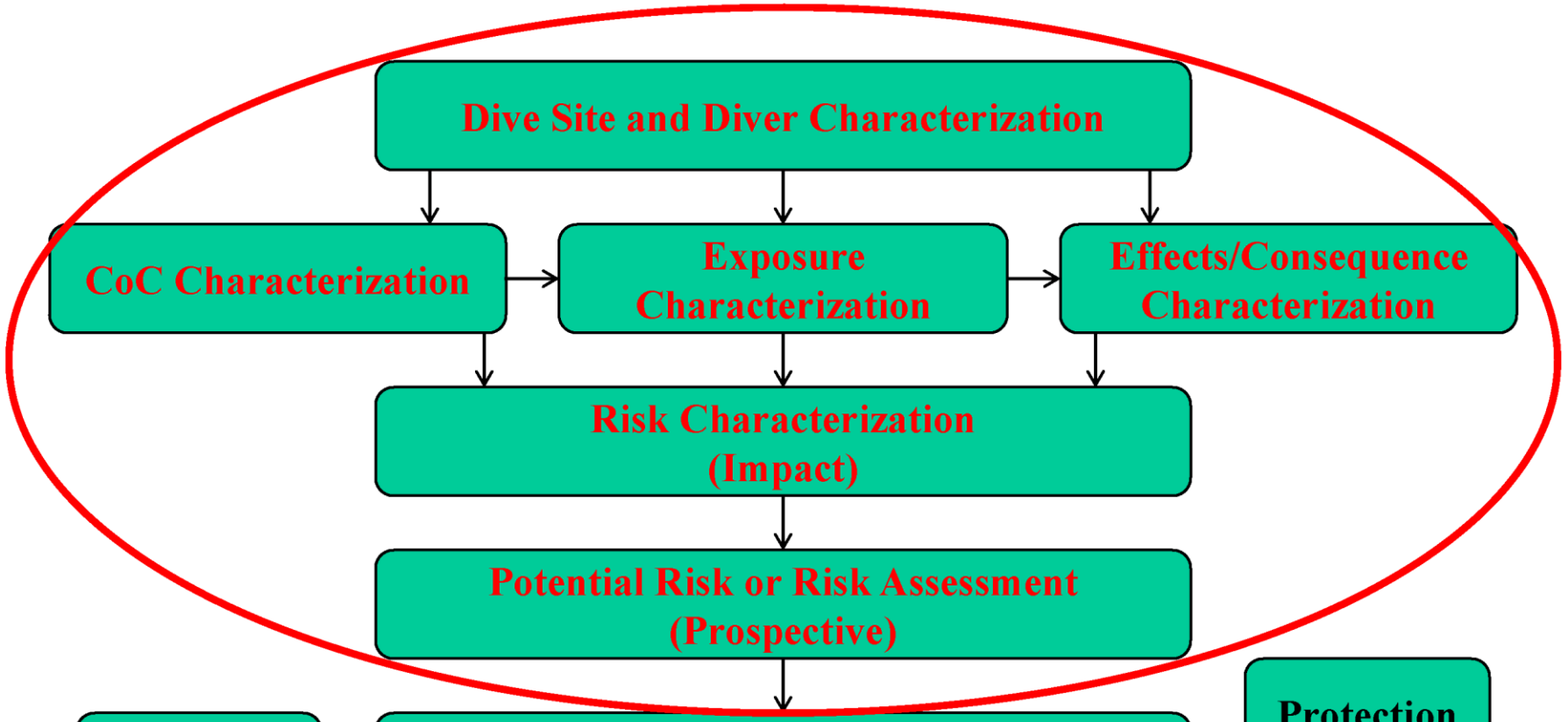


Mitigating Risk for any Given CoC*



* Contaminant of Concern

Evaluating Risk for any Given CoC



* Contaminant of Concern

Contaminated Water Diving Risk Characterization Matrix (RCM)

Possible **Consequence** Upon **Exposure** to **CoC**

Likelihood of Exposure to CoC

RCM for CoC	*Not Significant*	*Minor*	*Moderate*	*Major*	*Severe*
Nearly Certain					
Likely					
Probable					
Unlikely					
Rare					

Risk Level Evaluation

Contaminated Water Diving Risk Characterization Matrix (RCM)

Possible **Consequence** Upon **Exposure** to **CoC**

Likelihood of Exposure to CoC

RCM for CoC	***Not Significant***	***Minor***	***Moderate***	***Major***	***Severe***
Nearly Certain	Medium	High	Very High	Very High	Very High
Likely	Medium	High	High	Very High	Very High
Probable	Low	Low	High	High	Very High
Unlikely	Low	Low	Medium	Medium	High
Rare	Low	Low	Low	Low	Medium

Assessment Requirements:
Data/Information & *Dependencies*

Risk Topic 1	Risk Topic 2	Risk Topic 3	Risk Topic 4
Consequence	**CoC**	**Exposure**	**Likelihood**
– Type of Impact	– Type: • Chemical • Biological	– Route	– Frequency
– Adverse Effect Level	– Legacy	– Mechanism	– Duration
– Dependence on Human Endpoint (e.g. diver health)	– Prospective	– Acute	– Dive Op Type
	– Dive Site Conditions & Character-istics	– Chronic	– Dive Site Conditions & Character-istics
		– Dive Op Type	

Risk level evaluation relies on determining how well these dependencies and interdependencies are understood.

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Afternoon Risk Topics 1,2,3,4 Discussion Points

Initial topics/focal points for discussion

(The group can/will develop a consensus, prioritize, and modify these in more detail.)

Risk Topic 1: Type of Consequence Determination

- Impacts
  - Physiological?
  - Neurological?

Psychological – impact of contamination perception?

What can be said about Causality?

What about diver monitoring?

- Adverse Effects
  - General health?
  - Urgent vs Emergent
  - Longer Term result of exposure - Carcinogenic, mutagenic, etc.,
  - Under what conditions/route of exposure?
  - Distinguish between Consequence Levels:
    - "Not Significant" vs "Minor" vs "Moderate", "Major" vs "Severe"?
- Diver Characteristics affecting risk – differences based on:
  - Gender
  - Age
  - Body mass
  - Preexisting conditions

Risk Topic 2: Type of CoC Determination

- Types:
  - Chemical
  - Biological

Focus ↙ Exposure
Matrix Effects
(e.g. water vs sediment)

Acknowledge ↘ Radiological?

Physical?
(depth, pressure, temperature, e

- Legacy: What was there historically? What is there now?
- Prospective:
  - What could be there in the future?
  - What sources/local industries are present with potential direct input?
- Dive Site Conditions & Characteristics:
  - Availability for exposure? Are sources vs sinks for CoC present?
  - What controls CoC availability? General water quality? Sediments (oxic/anoxic, organic rich/poor), currents?

Risk Topic 3: Type of Exposure Determination

- Route/Mechanisms:
  - Ingestion?
  - Dermal? → - Through pores
    - Through lesions/cuts/scrapes
  - Sensitive membranes, e.g. eyes, ears, nasal?
  - Respiratory?
- Acute vs. Chronic:
  - What is the magnitude of exposure?
  - What is the typical dive time/duration of exposure
  - What type of CoC?
- Mitigating factors
  - Dive dress/gear type &/or potential protection/enhancement?

Risk Topic 4: Likelihood of Exposure Determination

- Dive Op Type:
  - How does the type of mission affect the potential for exposure?
  - How does the duration of diving op affect the potential for exposure?
  - How does the dive site conditions during diving op affect the potential for exposure?
  - How does the dive site characteristics during diving op affect the potential for exposure?
- What is the frequency of dive op at the site?
- Distinguish between
  - “Nearly Certain”, Likely”, “Probable”
  - “Unlikely” and “Rare”

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Backups →

Risk ➔ Adverse Effect

https://www.tdisdi.com/erdi-news/planning-a-contaminated-water-dive/

Workshop Goal Statement

Formulate the *data and information requirements* for using *a risk characterization approach* to determine the *impact to divers from contaminants of concern*, which can be applied at *any given site and dive scenario*, for purposes of *mitigating potential risk*.

Assessment Requirements:
Data/Information & *Dependencies*

Risk Topic 1

Consequence

- Type of Impact
- Adverse Effect Level
- Dependence on Human Endpoint (e.g. diver health)

Risk Topic 2

CoC

- Type:
  - Chemical
  - Biological
- Legacy
- Prospective
- Dive Site Conditions & Character-istics

Risk Topic 3

Exposure

- Route
- Mechanism
- Acute
- Chronic
- Dive Op Type

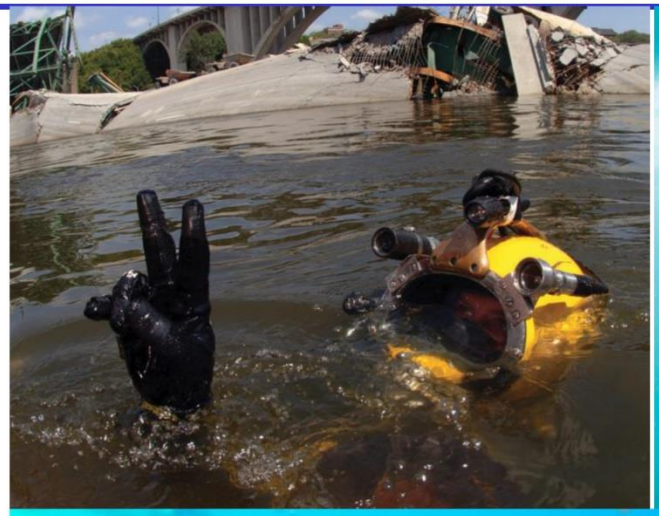
Risk Topic 4

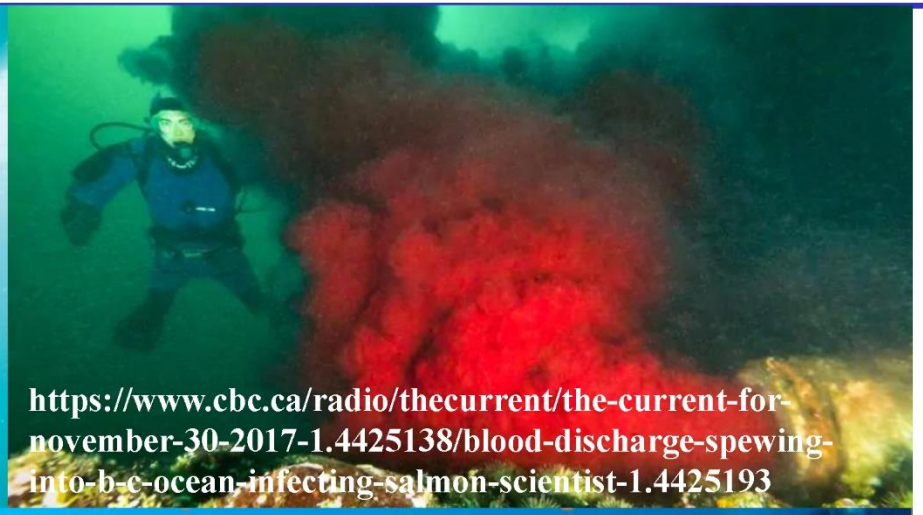
Likelihood

- Frequency
- Duration
- Dive Op Type
- Dive Site Conditions & Character-istics

Risk level evaluation relies on determining how well these dependencies and interdependencies are understood.

What is the Risk?





https://www.cbc.ca/radio/thecurrent/the-current-for-november-30-2017-1.4425138/blood-discharge-spewing-into-b-c-ocean-infecting-salmon-scientist-1.4425193

Contamination Risk for Underwater Divers (CRUD) Workshop

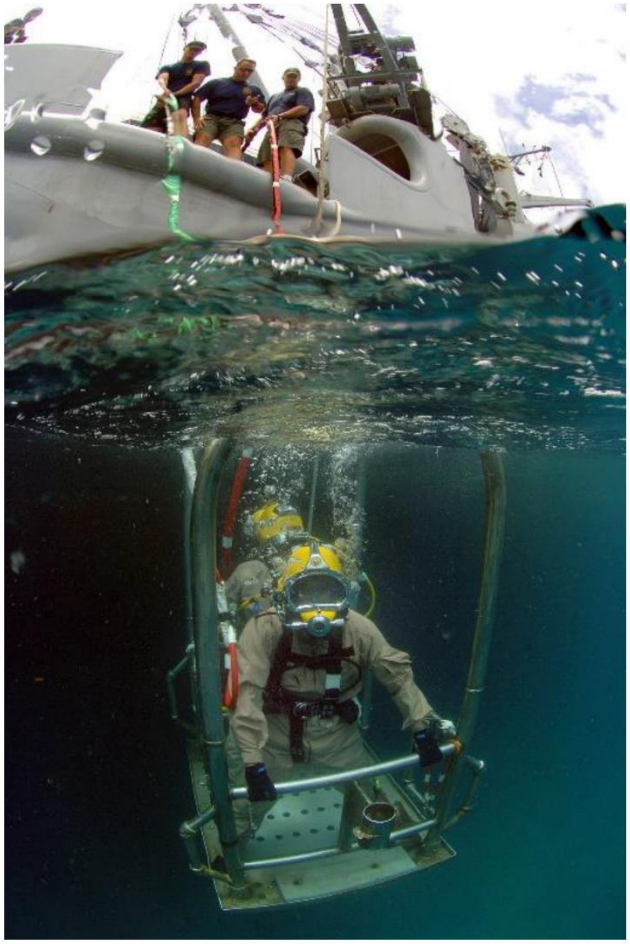
Occupational Exposure Risk Characterization Issues for Navy Divers

Paul Gillooly, Ph.D., MSC, CAPT, USN Ret

Al Philippi, D.O., MC, CAPT, USN Ret

Industrial Hygiene/Occupational Health

- **Industrial Hygiene (IH)**: Workplace Exposure Assessment
- **Occupational & Environmental Medicine**: Medical surveillance of employees potentially exposed to the hazards identified during the IH survey
- **Policy/Resources**: NAVOSH Program Manual (OPNAVINST 5100.23); Environmental Readiness Program Manual (OPNAV M 5090): Deployment Health Procedures (DODI 6490.3)
- **Exposure Recordkeeping**: DOEHRS/DOD and ILER/DOD-VA
- **Needed**: Specific exposure/risk assessment guidance/framework for in water exposures; U.S./Overseas Water Quality Database; defined hierarchy of controls.



Exposure Assessment:

- **Noise** (Single or double hearing protection)
- **Air compressor**: Noise, Carbon Monoxide, Diesel, Propane
- **Weapons** (M4 rifle/9 mm pistol)/weapons cleaning – lead
- **Chemicals**: Filling/emptying MK16 canisters, maintenance, cleaning dive gear (Respirators, Chemical splash gloves, goggles)
- **Radiofrequency Radiation** (radar)

Above the water

Below the water

State of the Science

- Good data regarding potential exposures/health hazards for Navy Divers above the waterline
  - IH Exposure Monitoring – Medical Surveillance
  - Guidance/Policy readily available
- Poor data regarding potential exposures/health hazards for Navy Divers below the waterline
  - No IH Monitoring
  - Need better guidance/policy on how to make Risk Management Decisions for Navy Divers
    - Very complicated proposition
    - Diverse exposures, hazards, and mission requirements

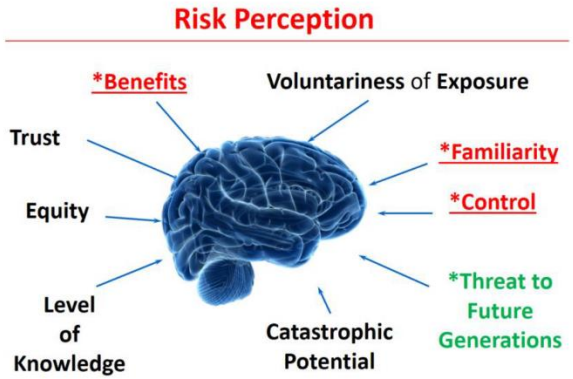
RESULT: Navy Divers are often "diving blind" regarding potential exposures to hazards in the water
- Chemical, physical, biological hazards
  - Typically can't be seen, smelled, felt or heard (so exposures/risks determined after-the-fact)

Key Data Gaps → Exposure Assessment

- No centralized water quality database is available for potential dive sites (especially a concern overseas)
  - Routine water quality indicators are often not available
    - pH, DO, Turbidity, ORP/Redox, Conductivity, Specific Conductance, Salinity, Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Ammonium, Ammonia, Chloride, Nitrate, Temperature
  - Surface water/sediment sampling with a focus on potential Navy Diver exposures is not included in many OEHSAs (Occupational & Environmental Health Site Assessments)
  - Chemical and biological data are typically not available
- Infrequent use of screening tools in the field for real-time water quality assessment
  - Tools are readily available for routine water quality parameters but less so for chemical/biological parameters
  - Very difficult to find DOD-certified, fixed labs overseas
- Lack of policy/guidance/funding for data collection on a regular basis to monitor water quality

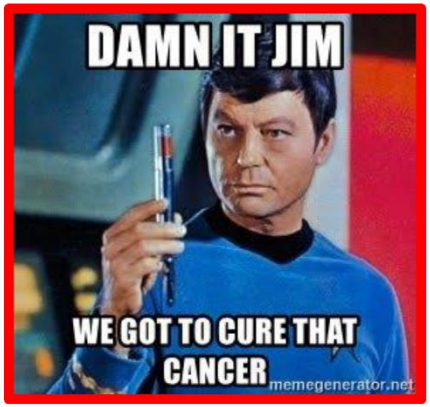
Risk Perception: the Fundamental Challenge!

- "There is virtually no correlation between the ranking of hazards by experts and the ranking of those same hazards by the public"
- Cut through the noise with Risk Communication (Social Science)
- Risk Perception Risk Factors (Control, Familiarity, Benefits)
- Facts vs Emotions: 80/20 Rule (Risk is inherently subjective)



Risk Perception: the Fundamental Challenge!

- **We don't see things as they are…**
- **Zero Risk Society**
- **CSI: CRIME SCENE INVESTIGATION**
- **Winning Feels Different in Risk Communication**



EPA's National Underwater Diving Safety Management Program

Contaminated Water Diving Workshop
March 5 and 6, 2020
EPA Dive Program Overview

Sean Sheldrake*, Training Director
Scott Grossman, Technical Director

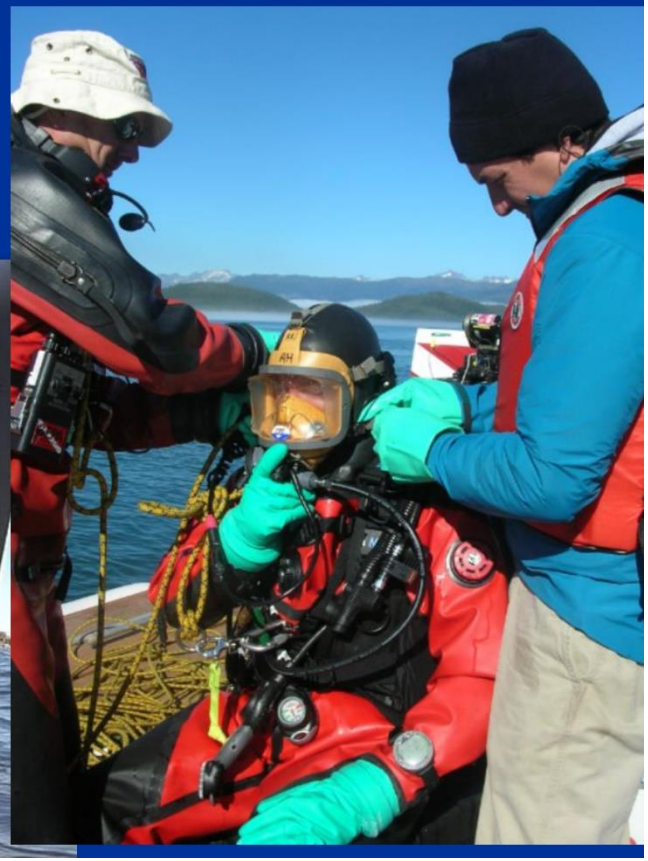
EPA SCIENTIFIC DIVING
www.epa.gov/scientific-diving

Training and Certification Levels

- Trainee Diver
  - EPA employee with <25 dives
- Scientific Diver
  - Minimum of 25 dives to enter training
  - Demonstrated proficiency in water skills
  - Pass EPA diving exam
- Divemaster
  - 100 logged official work and training dives
  - Completed Divemaster Training Course
  - Demonstrated proficiency with divemaster duties

EPA Dive Program Profile

- Current Number of Divers:
  - 62 Total current divers consisting of:
    - 34 Dive Masters
    - 26 Divers
    - 2 Trainee Divers
- Average 1,400 dives/year



Dive Units by EPA Region

Sean Sheldrake
Seattle, WA

T Chris Mochon-Collura
Newport, OR

Eric Nelson
Boston, MA

Scott Grossman
Edison, NJ

Steve Donohue
Philadelphia, PA

Mel Parsons
Chair, Diving Safety Board
Athens, GA

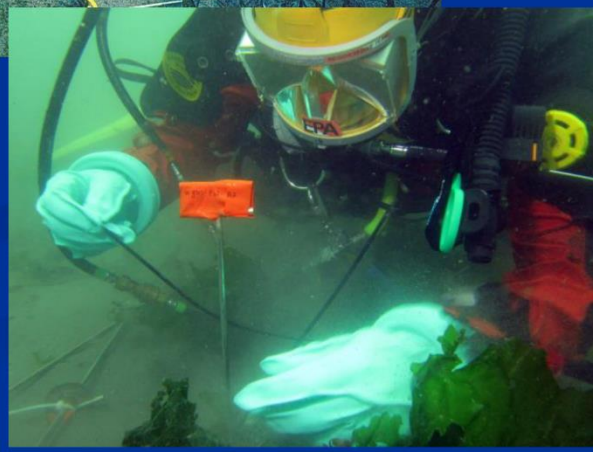
Tara Houda
Atlanta, GA

Ashley Howard
Dallas, TX

Cheryl Hankins
Diver Training Center
Sabine Island, FL

Focus Areas

- Survey & Sampling:
  - Ocean dredge disposal sites
  - Ocean outfall sites
  - Superfund/Contaminated water sites:
    - Groundwater
    - Porewater
    - Sediment
    - Biota Sampling
- Criminal enforcement investigations:
  - Harbors
  - Bridge construction
  - Dumping
  - Illegal disposals/discharge
  - Illegal resource extraction
- Research and Monitoring:
  - Coral reefs
  - Seagrasses
  - benthic and critical habitats.
- Emergency response: Spills, Columbia shuttle recovery.
- Internationally recognized expertise in polluted water diving.



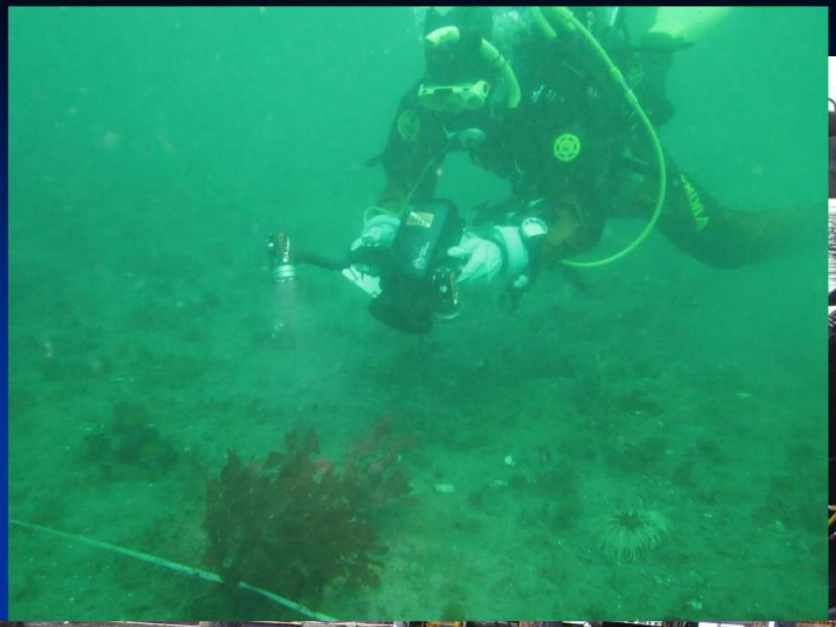
Types of Equipment Used

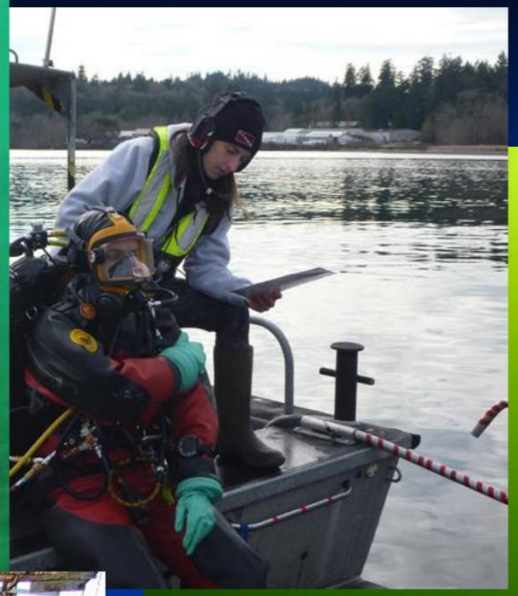
- All 9 EPA dive units utilize open circuit scuba.
- All members are certified in drysuits and full-face masks.
- 4 units use surface supply with helmets and/or full-face masks.
- All units have underwater communications: diver to diver and diver to surface.
- Annual dive training at EPA facility in Pensacola, Florida.

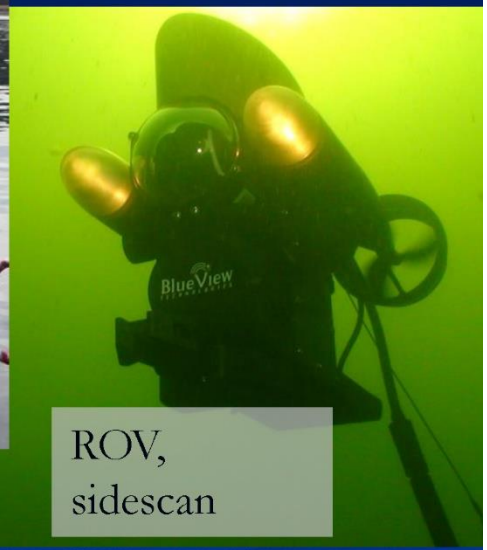
Space Shuttle Columbia Recovery Dives

EPA Training Center, Sabine Island, FL.

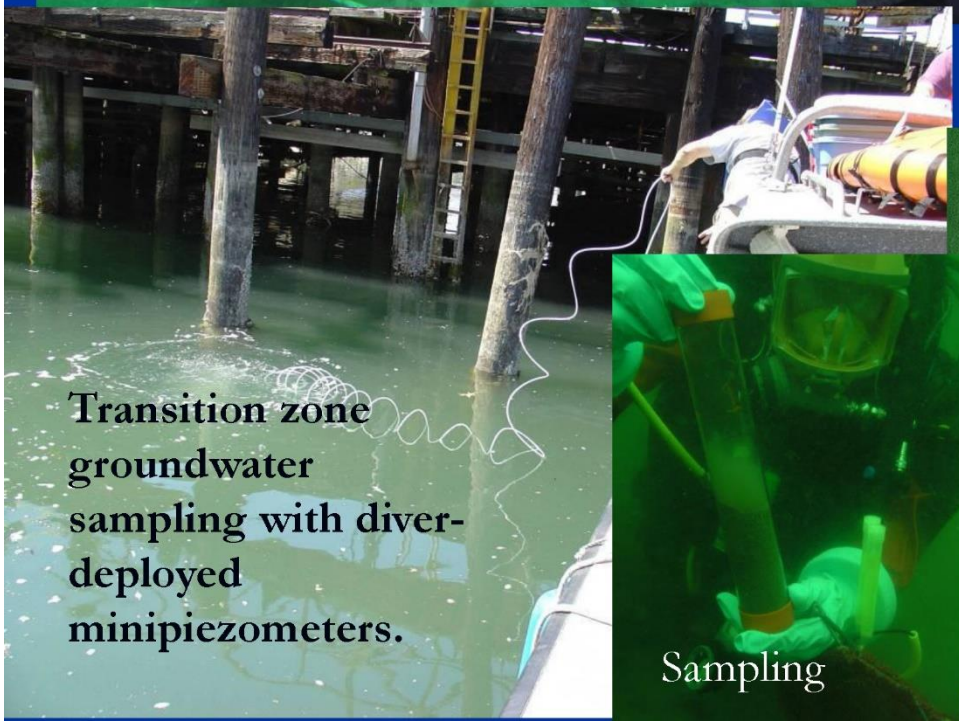
Capabilities - examples







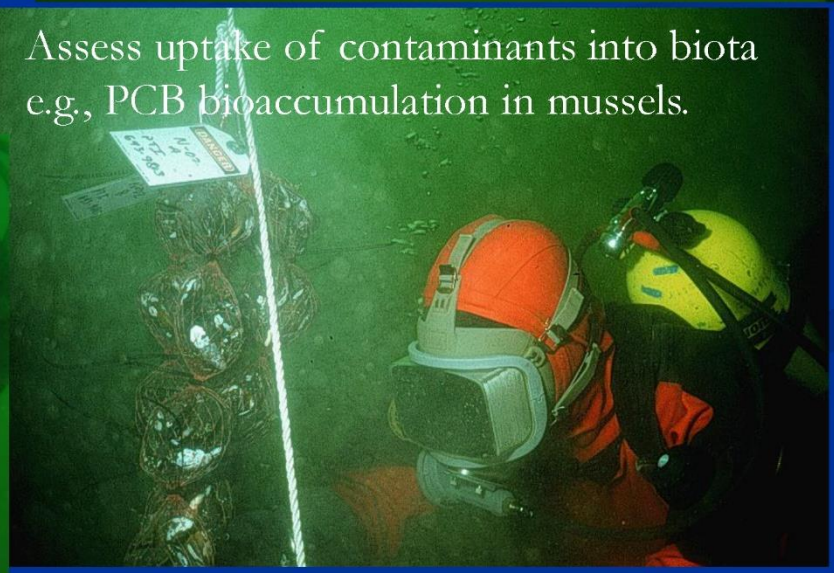
ROV, sidescan



Transition zone groundwater sampling with diver-deployed minipiezometers.

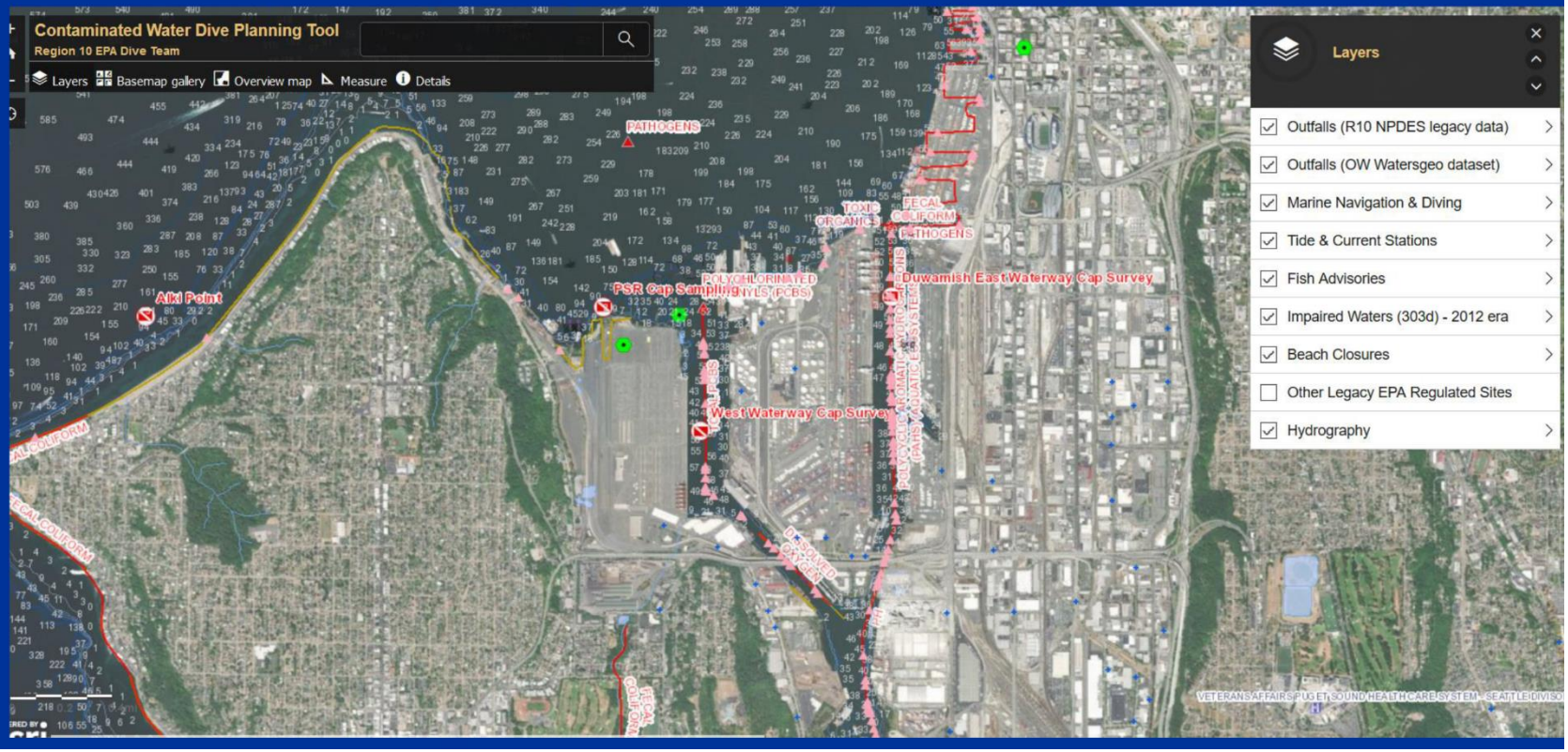
Sampling

Assess uptake of contaminants into biota e.g., PCB bioaccumulation in mussels.



Current focus areas

- (2019-2020) Integration of light work diving for mission work.
- (Ongoing) Outreach to the commercial, public safety, scientific, and federal dive communities on contaminated water training, medical surveillance, and tools available for dive planning.



Current focus areas, continued

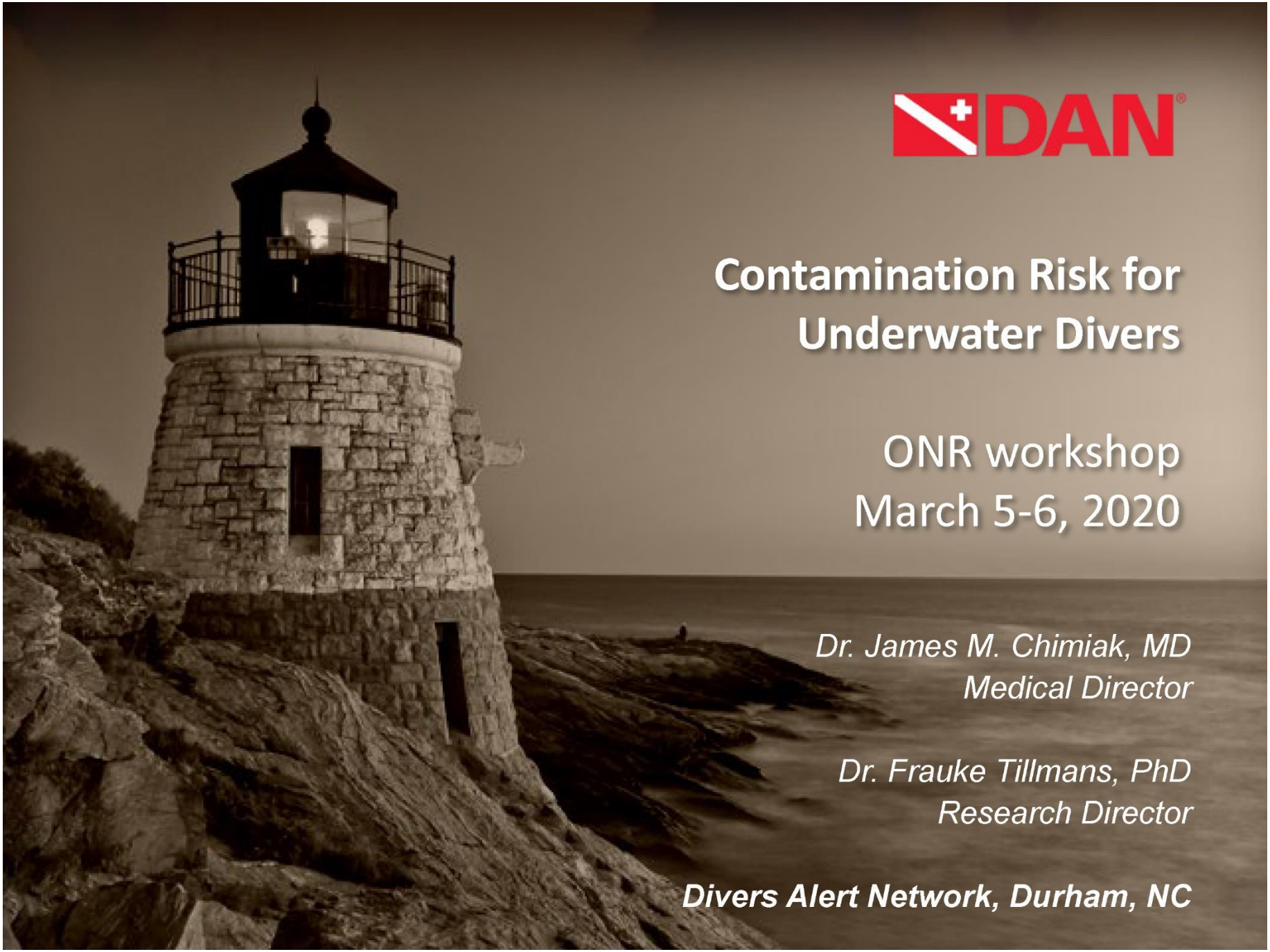
- (Ongoing) Medical monitoring issues related to contaminated water diving.
- (Ongoing) Improvement of decontamination techniques, PPE, and resources for polluted water diving, e.g. EPA GIS tools for dive planning.
- Expansion of contaminated water preparedness to all regional units.

Resources – contact information

See: epa.gov/diving

- Contaminated water, surface supply, and tethered SCUBA diving protocols;
- SOPs for decon.

- Sean Sheldrake, (206) 553-1220, sheldrake.sean@epa.gov
- Scott Grossman, (732) 261-1140, grossman.scott@epa.gov
- Mel Parsons, (706) 355-8714, parsons.mel@epa.gov


DAN
Contamination Risk for Underwater Divers
ONR workshop
March 5-6, 2020
Dr. James M. Chimiak, MD
Medical Director
Dr. Frauke Tillmans, PhD
Research Director
Divers Alert Network, Durham, NC

DAN
DIVERS ALERT NETWORK

Divers Alert Network (DAN)

DAN's Mission

DAN helps divers in need of medical emergency assistance and promotes dive safety through research, education, products and services

DAN
DIVERS ALERT NETWORK

DAN's potential contributions to CRUD

- Expertise in
  - Diving Injuries & Incidents
  - Diving Medicine
  - Human Biology/Physiology
- Networking and Collaboration
  - Medical Specialists
  - Research Scientists
  - Volunteer Divers
- Funding (competitive grant program)

DAN
DIVERS ALERT NETWORK

CONTACTS

- Dr. Jim Chimiak
  Medical director
  jchimiak@dan.org
- Dr. Frauke Tillmans
  Research Director
  ftillmans@dan.org
- Francois Burman (not present)
  Director of Underwater & Hyperbaric Safety
  fburman@dan.org

DAN
DIVERS ALERT NETWORK

Medical Director, DAN
Dr. Jim Chimiak

No conflicts of interest

Great interest in this conflict!

- Contaminated Diving-CWPDS, CBN warfare, contaminated sat diving and diving instruction
- Navy Special Operations Officer
- Saturation Diving Medical Officer
- Flight Surgeon
- Med School Residency - UNC, DUKE
- Trained: Primary care, emergency, intensive care, occupational med
- Boarded: Anesthesiology, Hyperbaric, Pain Med

Your Dive Safety Association

DAN
DIVERS ALERT NETWORK

Research Director, DAN
Dr. Frauke Tillmans

Background:

- PhD in human biology
- EMT, Firefighter
- Scientific Diver / Dive Safety Officer
- Public Safety Diver

Functions at DAN:

- PI in diver-centric research projects
- Grant Program Administration
- Member of Research and IRB Committee

Your Dive Safety Association

DAN
DIVERS ALERT NETWORK

Director of Underwater & Hyperbaric Safety, DAN

Francois Burman

Background:

- Pr. Eng, IntPE (SA), BSc Eng (Mech), MSc (MedSc), MSAIME, FSAIW

Functions at DAN:

- Develop and manage risk mitigation programs for diving professionals, diving businesses and hyperbaric treatment centres around the world

Your Dive Safety Association

DAN
DIVERS ALERT NETWORK

DAN

- 24/7 ongoing database of diving injuries and incidents worldwide
- Research projects focused on diver health issues
- Identification/quantification of exposure, work-up and long-term follow-up of diver health challenges

DAN
DIVERS ALERT NETWORK

DAN's Network

- Interface with diving organizations - rec, PSD, military, EPA, NOAA, NASA
- Rec/Tech diver interests
  - Mercury, lead
  - Nuclear
  - Algae
  - Bacteria
  - Piers

DAN
DIVERS ALERT NETWORK

CRUD Problems and Challenges

Risk vs Benefit

- Hazards
  - Qualified manned studies
    - Short term
    - Long term
  - Equating to expected exposure
- Reliable testing/identification of environment
- Cost effective (safe) protection
  - Actually protects against agent
  - Dwell time

DAN
DIVERS ALERT NETWORK

CRUD Problems and Challenges

Risk vs Benefit

- Effective decon vs discard
- Protection of topside personnel/tenders
  - Contamination topside environment
- Surveillance-proper cohort for divers
  - Short term
  - Long term
  - Effective cohort

DAN DIVERS ALERT NETWORK

Specific Issues

- Consolidation of global contamination GIS data
  - Location of website
  - Access w/o adequate training? undue alarm
- Medical Surveillance of diver-up to 20-30 yrs; acute vs chronic problems
  - Central location
  - Potential Navy study,Dr. McAdams-duration?
    - Investigate other diver study data bases- Curley

DAN
DIVERS ALERT NETWORK

Issues

- Point of contact- Dr Southerland/Regis
  - Close network with other SMA
- DAN to consider role to facilitate establishment of long term program
- Ongoing tasking for PPE improvement-do not forget COC ability to quickly permeate through barrier protection-Industrial Hygienist
  - Lighter/tougher-thermal and abrasion
  - Cooling- consider consequence on dermal absorption, infection, decompression stress and comfort (work capacity); measure **core** temp ? Thermal pill
  - Leak test procedures, include full Kaki test

DAN
DIVERS ALERT NETWORK

Issues

- Critical review of monitors
  - Too good to be true- remember Theranos
  - Look at false positive and what you are looking at- positive small pox and plague what would you do?
- **CONTAMINATION THRESHOLD LIMITS**
  - Most crucial determination-potable water limits vs watersport limits
  - Increase with increasing PPE protection
    - Risk to totally encapsulated diver

DAN
DIVERS ALERT NETWORK

Issues

- Study specialize diving population
  - Inshore/harbor/hull cleaning divers: port contamination, defouling paints, creosol exposures
  - Golf ball divers- fertilizer, herbicide,

DAN
DIVERS ALERT NETWORK

Issues

- Specific contamination diving teams for known high risk, urgent dives
  - Examples CBRN response teams
  - Expert, quicker dive completion, less risk of botching protective procedure
  - Medical surveillance better, confined group, better reporting w/better COC ID
  - Downside is not always locally available
    - All divers trained, but at lesser level similar to CBR trg

DAN DIVERS ALERT NETWORK

Issues

- Medical Intelligence
  - On line GIS
  - Govt agencies to include CDC, NIH, EPA etc
  - Local health authorities
  - Local recreational diving and watersports
  - Military medical intelligence Units
  - Need for a POC to assist if difficulties
  - Prevention
    - Immunizations
    - Antibiotic selection

DAN
DIVERS ALERT NETWORK

Cases Documentation-OILS

- To be conducted going forward
- Cases suspected have been GI symptoms, dizziness and skin infections.
  - Long term problems unknown; COC ID are unknown
  - Review all OILS contamination(Oral, Inhalational, Lasting(residual in garment/environment), Skin
- Proposed 10K Navy diver study to record all suspected cases along with diver health surveillance per Dr Southerland

DAN
DIVERS ALERT NETWORK

DAN Publications

- Send us any article of interest if you desire its publication on DAN website or on Alert Diver

DAN
DIVERS ALERT NETWORK

Divers Alert Network (DAN)

(919) 684-2948

Dr. Jim Chimiak, MD
Medical Director
jchimiak@dan.org
Tel ext. 1246

Dr. Frauke Tillmans, PhD
Research Director
ftillmans@dan.org
Tel. ext. 1637

Your Dive Safety Association

NOAA Diving Program

Diving for Science and Technology

Commander Eric Johnson, NOAA

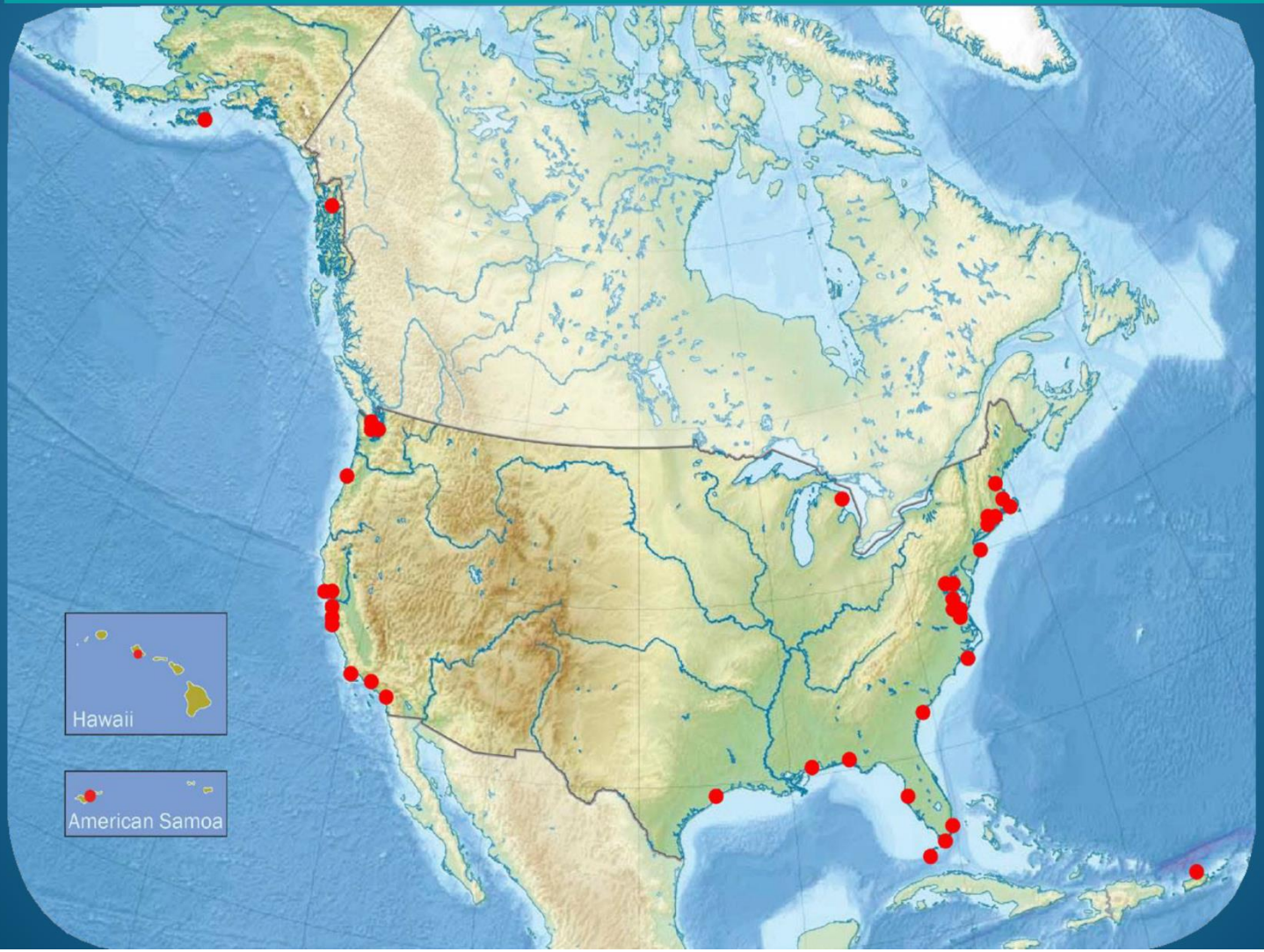
NOAA Diving Program

Office of Naval Research

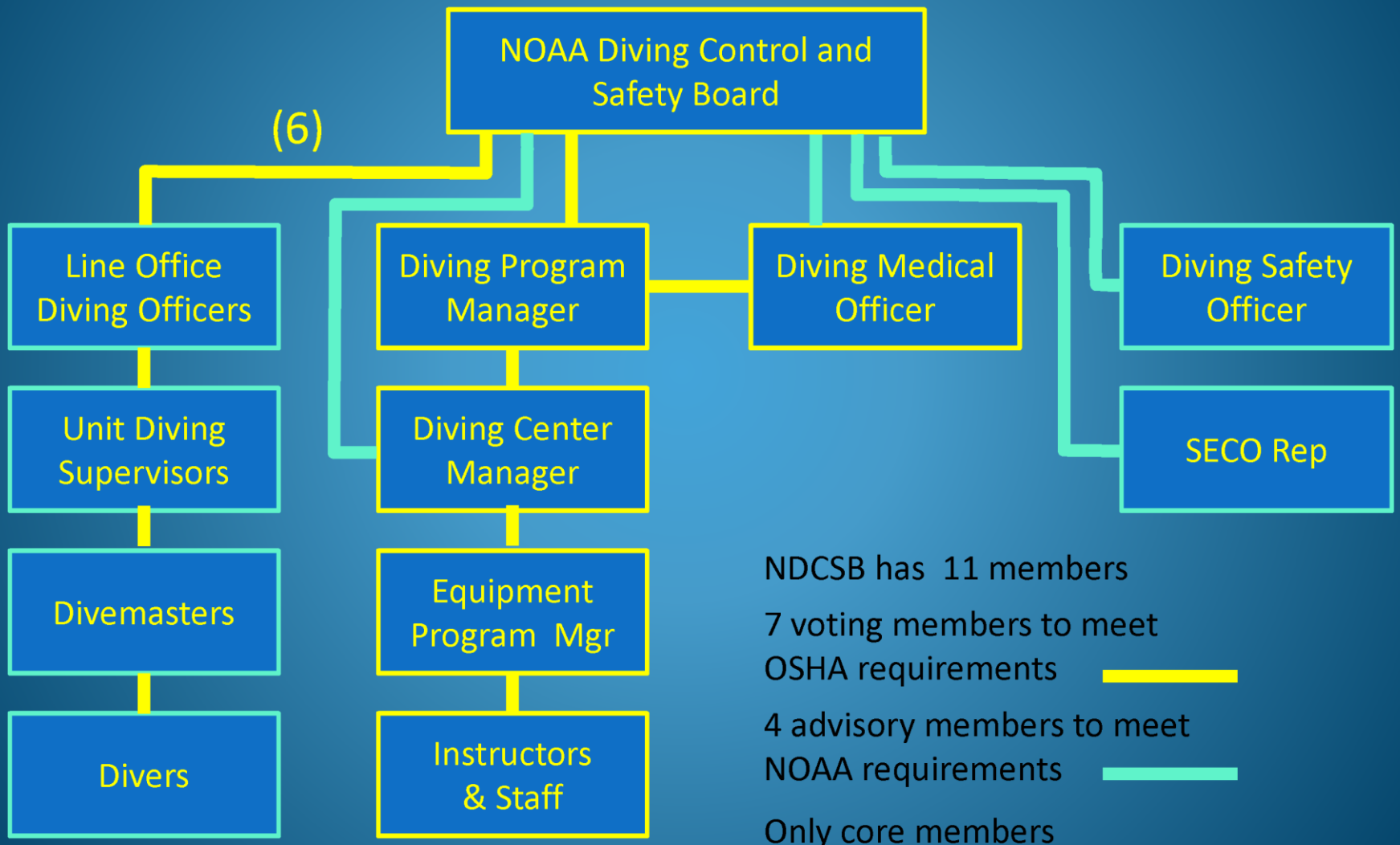
Contamination Risk for Underwater Divers

Arlington, VA 5-6 Mar 2020

50 Diving Units
34 Shore Based, 16 Ship Based

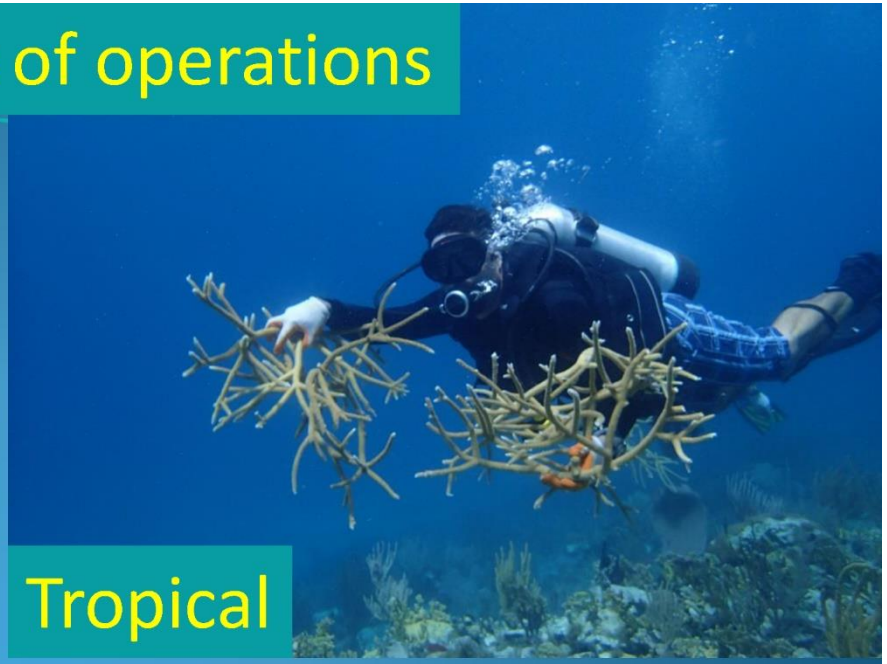


Organizational Structure



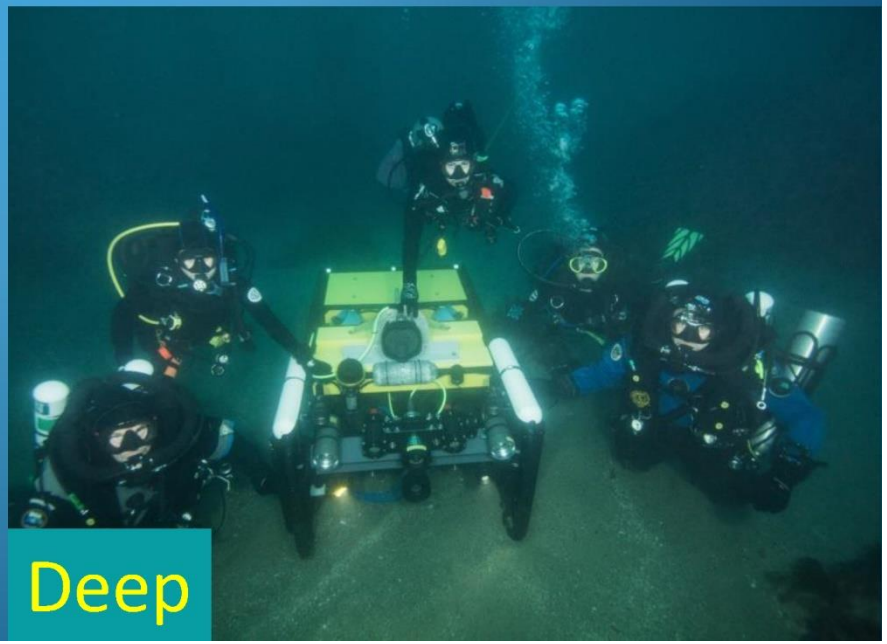
Very wide range of operations

Polar



Tropical

Shallow



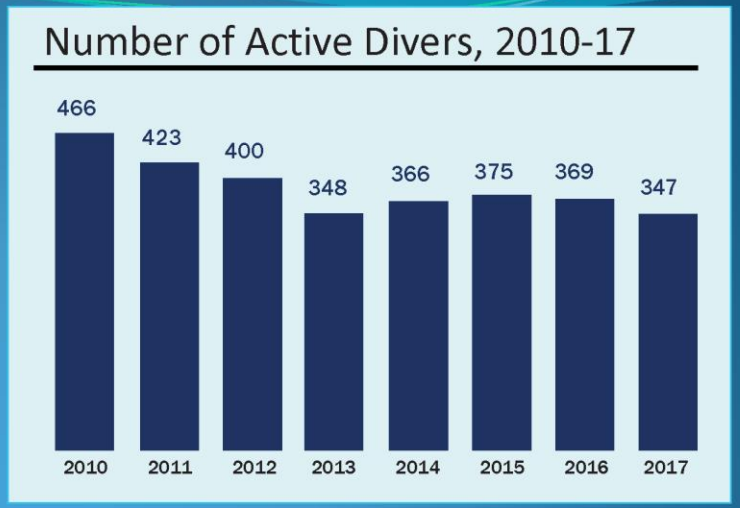
Deep

Metrics

Decompression

No Deco 98%

Deco 2%



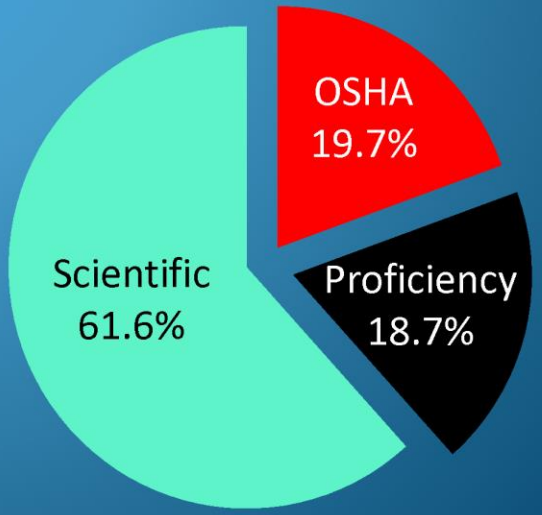
Breathing Gas

Air 64%

Nitrox 35%

Trimix 1%

Dive Designation



Mode

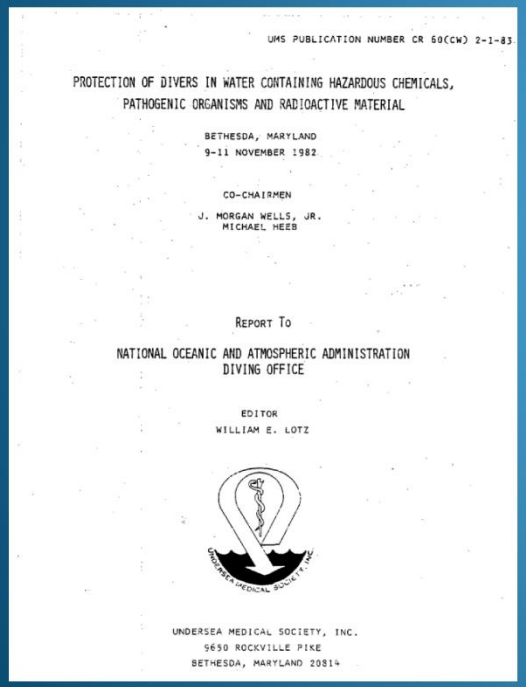
Open Circuit 95%

Closed Circuit 5%

Initial NOAA work in CRUD

Equipment development for diving in polluted and hot water environments was conducted in the late 1970s

More recent NOAA work in CRUD



UMS PUBLICATION NUMBER CR 60(CW) 2-1-83

PROTECTION OF DIVERS IN WATER CONTAINING HAZARDOUS CHEMICALS, PATHOGENIC ORGANISMS AND RADIOACTIVE MATERIAL

BETHESDA, MARYLAND
9-11 NOVEMBER 1982

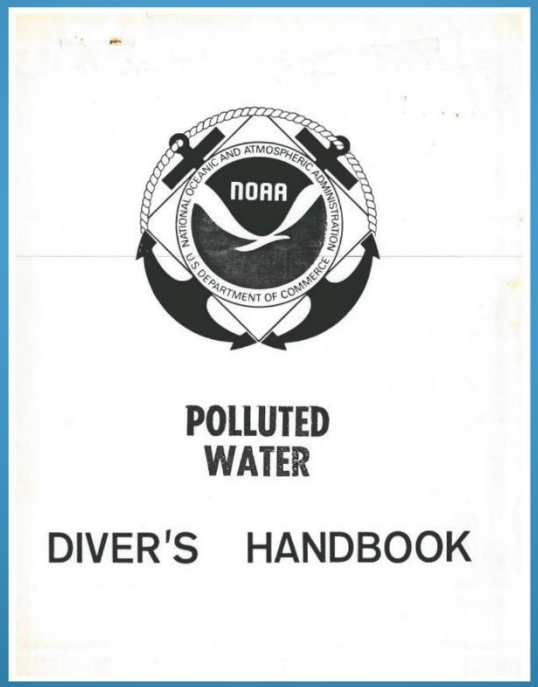
CO-CHAIRMEN
J. MORGAN WELLS, JR.
MICHAEL HEEB

REPORT TO
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
DIVING OFFICE

EDITOR
WILLIAM E. LOTZ

UNDERSEA MEDICAL SOCIETY, INC.
9650 ROCKVILLE PIKE
BETHESDA, MARYLAND 20814

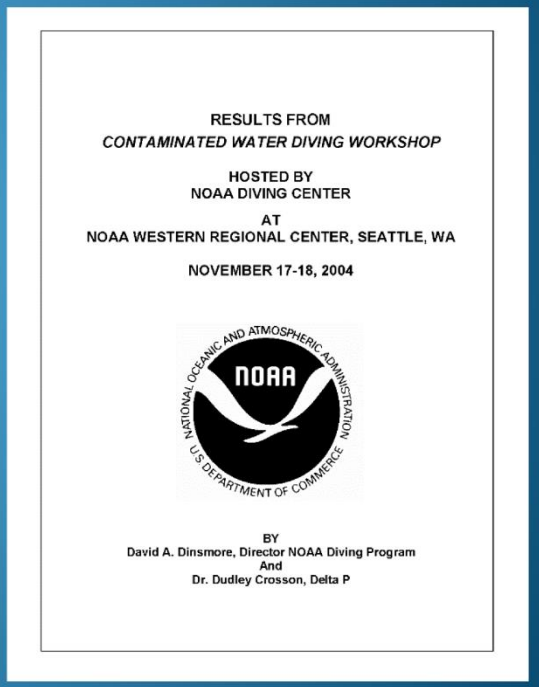
1982



POLLUTED WATER

DIVER'S HANDBOOK

1982



RESULTS FROM
CONTAMINATED WATER DIVING WORKSHOP

HOSTED BY
NOAA DIVING CENTER
AT
NOAA WESTERN REGIONAL CENTER, SEATTLE, WA

NOVEMBER 17-18, 2004

BY
David A. Dinsmore, Director NOAA Diving Program
And
Dr. Dudley Crosson, Delta P

2004

Current position on Contaminated Water diving

Section 4.15 Contaminated Water Diving

Diving in water known or suspected to be contaminated with hazardous biological, chemical, or radioactive pollutants requires specialized training, equipment, and diving protocols and is outside the scope of the NDP. Until such time that these elements are established, NOAA divers are prohibited from diving in contaminated water. Qualified contract divers should be hired to dive in these conditions.

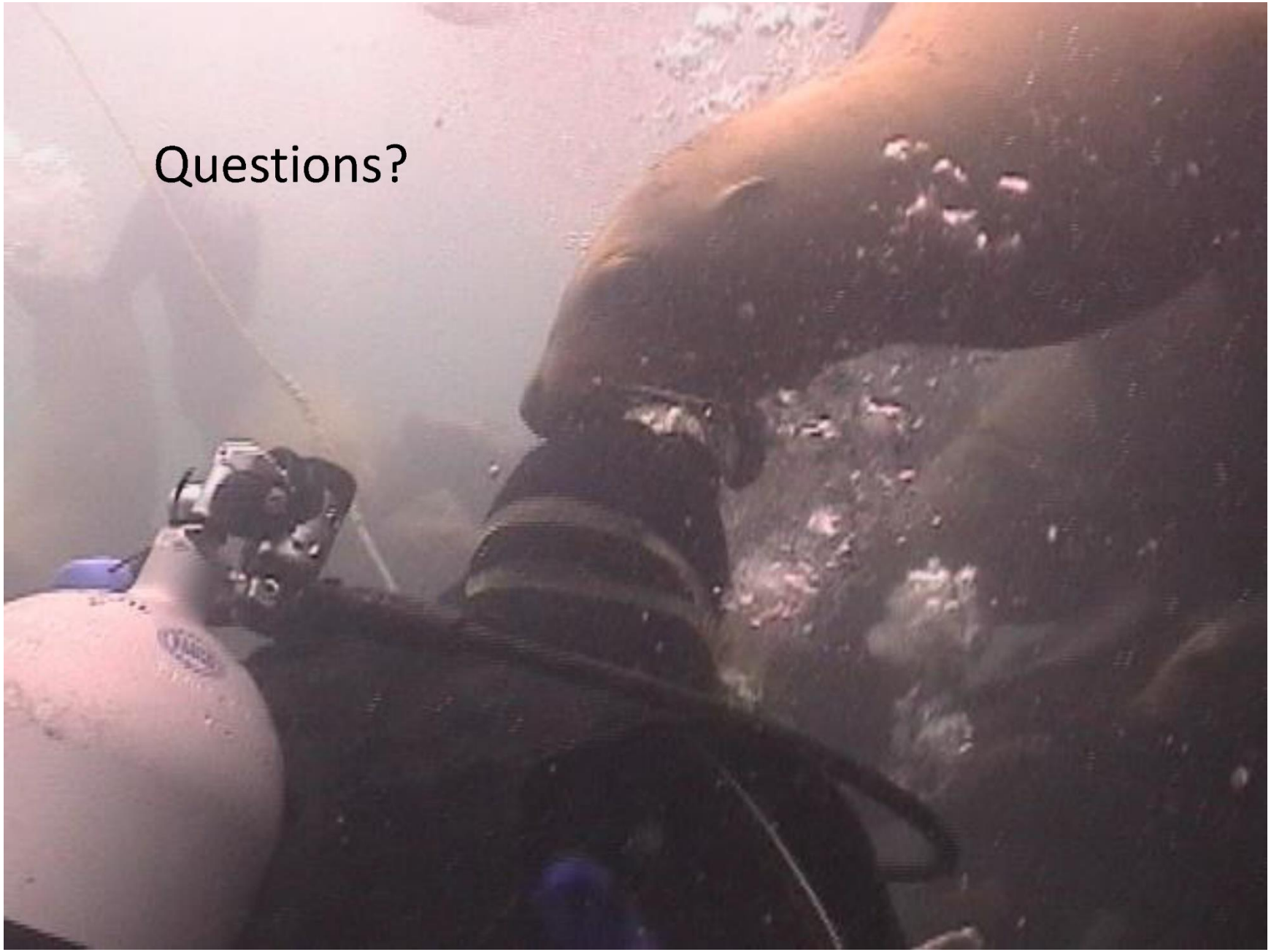
Current position on Contaminated Water diving

Section 4.15 Contaminated Water Diving

Diving in water known or suspected to be contaminated with hazardous biological, chemical, or radioactive pollutants requires specialized training, equipment, and diving protocols and is outside the scope of the NDP. Until such time that these elements are established, NOAA divers are prohibited from diving in contaminated water. Qualified contract divers should be hired to dive in these conditions.

NOAA Diving concerns with Contaminated Water Diving

- On-site determination of water contamination – which contaminants are present, what is level of contamination .
- Appropriate PPE and decontamination procedures.
- Medical response – immediate on-site as well as long term.
- Medical monitoring – parameters to monitor and duration of monitoring.
- Legal requirements – notification of divers, long-term monitoring, worker's compensation (FECA).
- FTEs vs Contractors?

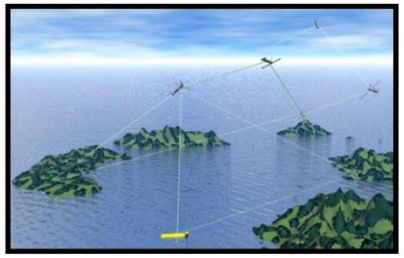

Questions?


Human Systems Directorate
Overview
Ms. Jen Coughlin
Senior Environmental Sciences Support Analyst
Office of the Under Secretary of Defense
(Research & Engineering)
CRUD Workshop
March 5, 2020
https://www.CTO.mil
@DoDCTO

USD(R&E) Mission

- Ensure Technological Superiority for the U.S. Military
  - Set the technical direction for the Department of Defense
  - Champion and pursue new capabilities, concepts, and prototyping activities throughout the DoD research and development enterprise
- Bolster Modernization
  - Pilot new acquisition pathways and concepts of operation
  - Accelerate capabilities to the warfighter

"Our mission is to ensure that we, if necessary, reestablish and then maintain our technical advantage."
– Under Secretary Griffin, April 2018



Modernization Priorities

There is a Portfolio Manager (Assistant Director) who is responsible for establishing the DoD-wide, mission-focused strategy and execution plan for each modernization priority

- Hypersonics
- Fully Networked Command, Control, and Communication
- Directed Energy
- Cyber
- Space
- Quantum Science
- Machine Learning / Artificial Intelligence
- Microelectronics
- Autonomy
- Biotechnology

"We cannot expect success fighting tomorrow's conflicts with yesterday's weapons or equipment."
– National Defense Strategy

DDRE(R&T) Mission

- Posture R&D Enterprise to create technology advantage
  - Resource cross-cutting and joint research
  - Seed pursuit of new technology areas based on analysis of emerging strategic environment
  - Facilitate the advancement, protection and transition of technology

HSD: Ensuring DoD Maximizes S&T for Warfighter Lethality

Our Focus is the Warfighter—DoD's most complex and versatile platform

Vision: Superior Warfighter lethality in all domains through innovative S&T research and policy

Mission: Frame, shape, integrate, and oversee DoD research investment, policies, and practices to ensure Warfighter dominance across all military operations

HSD Integrates DoD Research Activities for Optimal Warfighter Performance

DoD's central point of integration for all aspects of S&T for warfighter effectiveness and the lead for DoD in convening Services and Agencies to ensure unity of effort.

Distribution Statement A: Approved for Public Release

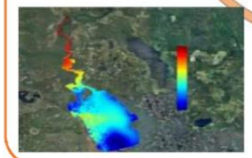
6

HSD Core Approach, Processes, and Products

Perceive Accurately	Think Strategically	Consult Broadly	Advocate Effectively	Communicate Persistently
				
Review strategic guidance and engage across ~$3.2B DoD research portfolio to understand alignment with current and future warfighter requirements	Identify strategic trends and potential opportunities for future research to address critical gaps in DoD knowledge or capability	Engage with SMEs and end users; convene meetings with stakeholders to explore issues, build research partnerships, and share knowledge	Identify and build support for new investments, activities, and opportunities for collaboration to close gaps in existing research portfolio and leverage future innovations	Disseminate reports, memos, briefings, issue papers, and other products to advance S&T policy, the state of the science, and DoD research activities/impact

Environmental S&T Vision


Understand the Environment...



So that DoD Equities and Operations...





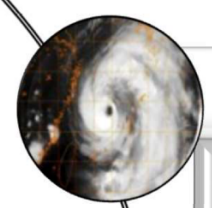
Maintain lethality despite environmental hazards and stressors...

And are effective, compliant, and sustainable.



Distribution Statement A: Approved for Public Release

Environmental Sciences



Environmental Situational Awareness

Goal: Understand and elucidate how environmental factors affect current and future military operational environments

Sustainable, Compliant Military Systems

Goal: Ensure environmental resiliency, sustainability, and compliance of current and future military missions and platforms

Environmental Hazard Protection and Mitigation

Goal: Prevent, protect, reduce, and mitigate environmental hazards (CBRN, TIC/TIM, etc.) across military operations

DoD Research and Engineering Enterprise

Creating the Technologies of the Future Fight

DoD Research and Engineering Enterprise
https://www.CTO.mil/

Twitter
@DoDCTO

National Center for Emerging and Zoonotic Infectious Diseases

Healthy Swimming

Don Sharp, MD, DTM&H

Michele Hlavsa, RN, MPH

Kevin O'Loughlin, MD

National Center for Environmental Health

Art Chang, MD, MS

John Sarisky, MPH

CRUD Workshop
March 5–6, 2020

CDC's Healthy Swimming Program

- **Cross-Center effort, primarily**
  - National Center for Emerging and Zoonotic Infectious Diseases
  - National Center for Environmental Health (NCEH)
- **Vision**
  - Minimize risk of illness, injury, disability, and death associated with swimming

Promoting Healthy Swimming

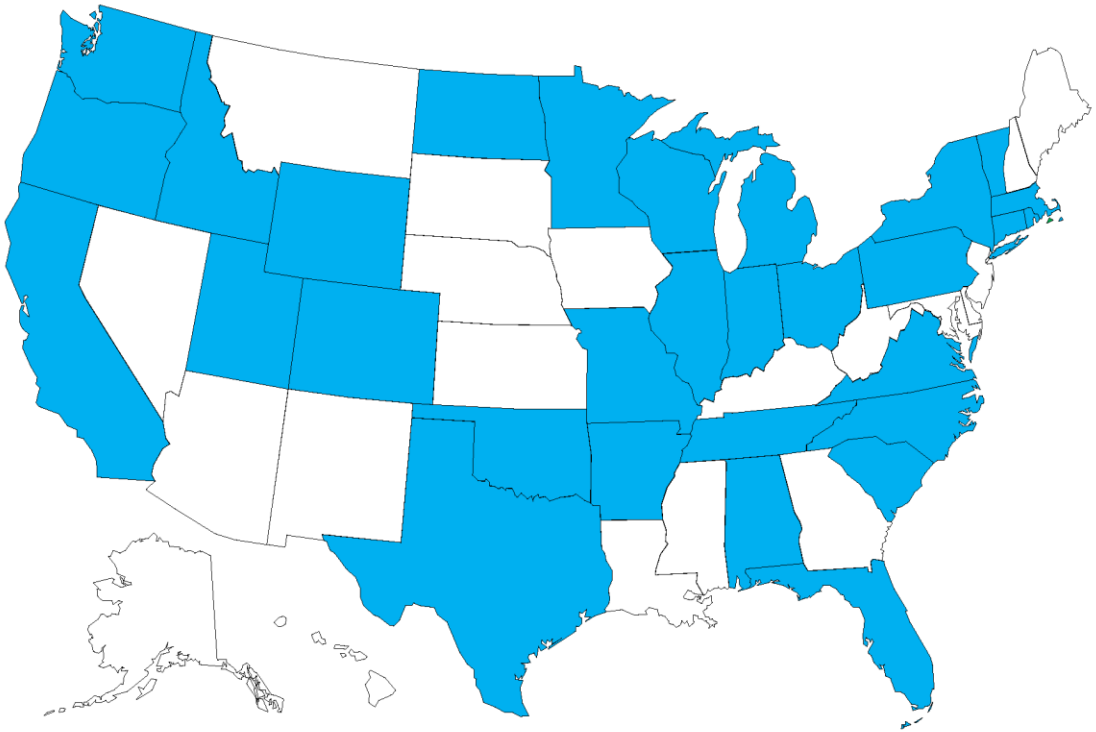
- **Analyze and regularly publish national surveillance data**
  - National Outbreak Reporting System (NORS)
  - One Health Harmful Algal Bloom System (OHHABS)
  - National Case Surveillance (e.g., *Naegleria*)
- **Conduct behavioral, environmental health, epidemiologic, and microbiologic studies**
- **Translate scientific data into evidence-based communications**
- **Leverage scientific data into evidence-based policy**
  - Treated (e.g., pools): CDC's Model Aquatic Health Code
  - Untreated (e.g., lakes): U.S. Environmental Protection Agency

Untreated Recreational Water–associated Outbreaks United States, 2009–2017

- **≥2 persons linked by location and time of exposure to pathogens, toxins, or chemicals in**
  - Recreational water
  - Air surrounding recreational water
- **98 untreated recreational water–associated outbreaks**
  - Resulting in 4,542 cases, 80 hospitalizations
- **Leading confirmed causes**
  - Norovirus: 17 outbreaks, 1,621 cases
  - *Shiga* toxin–producing *Escherichia coli*: 15 outbreaks, 140 cases
  - *Cryptosporidium*: 13 outbreaks, 138 cases
  - *Shigella:* 12 outbreaks, 702 cases

Source: NORS Dashboard (https://wwwn.cdc.gov/norsdashboard/), data queried March 4, 2020

Untreated Recreational Water–associated Outbreaks, by State—United States, 2009–2017 (n=98)*

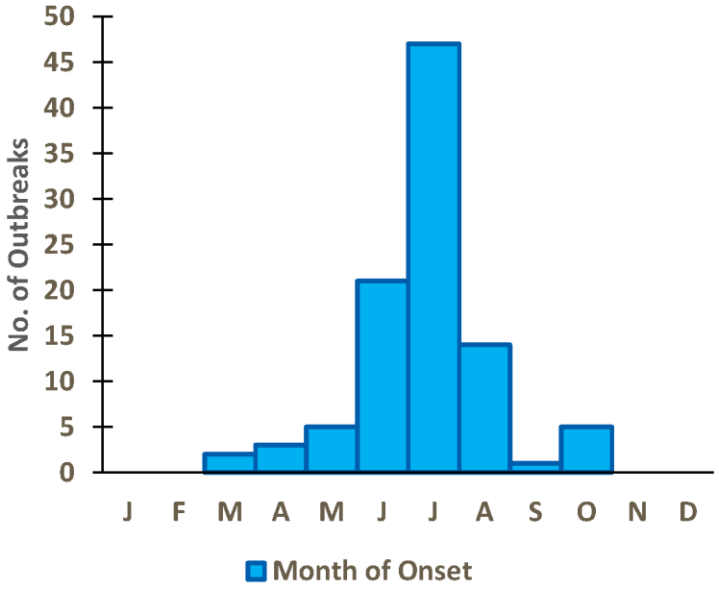


- 30 states voluntarily reported outbreaks

* Outbreak reporting to CDC largely dependent on public health capacity and reporting requirements, which vary across jurisdictions and do not necessarily indicate true incidence in given jurisdiction

Source: NORS Dashboard (https://wwwn.cdc.gov/norsdashboard/), data queried March 4, 2020

Untreated Recreational Water–associated Outbreaks, by Month of Onset—United States, 2009–2017 (n=98)



- Most outbreaks started during June–August (82 [84%])

Source: NORS Dashboard (https://wwwn.cdc.gov/norsdashboard/), data queried March 4, 2020

Harmful Algal Bloom (HAB)

- **HAB toxins can cause human and animal illness if ingested, inhaled, or come in contact with skin**
- **One Health issue**
  - Recognize interconnection among people, animals, plants, and shared environment
- **Emerging public health issue**
  - Contributing factors: warming climate, nutrient pollution

Source: Wisconsin Department of Health Services

Source: California Department of Public Health, Kai Schumann

HABs: Tracking Outbreaks, Illness, and Events

- **14 outbreaks confirmed or suspected to be caused by cyanotoxins during 2009–2017***
  - Resulting in 271 cases
  - Reported by NY, OH, UT, WA
- **OHHABS launched in 2016**
  - Collects data on individual cases of human or animal illness and freshwater and marine harmful algal bloom events
  - Anticipate first summary of OHHABS data to be published in 2020

*Source: NORS Dashboard (https://wwwn.cdc.gov/norsdashboard/), data queried March 4, 2020

NCEH HABs Activities

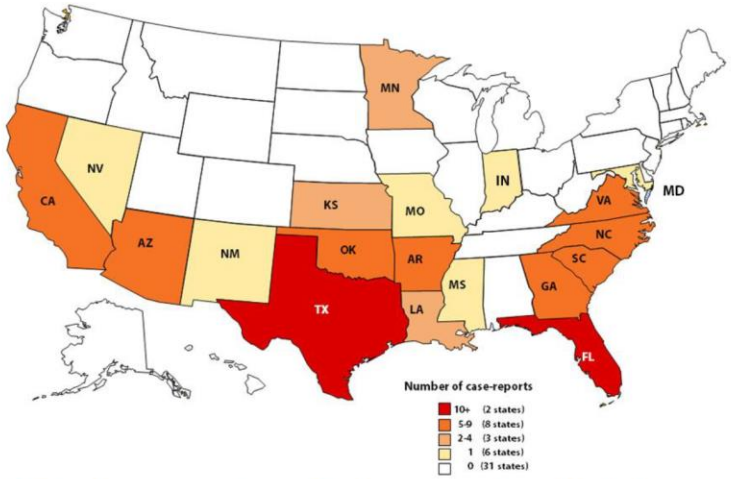
- Laboratory activities
  - Develop methods to detect cyanotoxins in clinical specimens
- Epidemiology and toxicology activities
  - Conduct study of CyanoHAB aerosols
  - Explore use of electronic health records
  - Enhance quality of poison control center data
- Partnerships
  - State and local public health agencies
  - American Association of Poison Control Centers
  - Environmental health practitioners

Copco Reservoir study May 2015
Photo by Lorraine Backer

National Case Surveillance: *Naegleria fowleri*

- ***Naegleria* commonly found in freshwater**
  - Infects people when water containing ameba enters nose
  - Destroys brain tissue → brain swelling and death
- **Fatality: 141 (97%) of 145 patients died during 1962–2018**
- **2009–2018: 30 (88%) infections associated with recreational water**

Number of Reports of Cases of Primary Amebic Meningoencephalitis, by State of Exposure United States (N=145)*



*State of exposure unknown for 4 cases, map doesn't include 1 case from U.S. Virgin Islands

Source: https://www.cdc.gov/parasites/naegleria/index.html

For more information, contact CDC
1-800-CDC-INFO (232-4636)
TTY: 1-888-232-6348 www.cdc.gov

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

Smithsonian Scientific Diving Program

Smithsonian Scientific Diving Program

Central Diving Office

Scientific Diving Officer: Douglas R. Schleiger
Assistant Scientific Diving Officer: Laurie M. Penland

Smithsonian Diving Units

- National Museum of American History, DC
- National Museum of Natural History , DC
- National Zoological Park , DC
- Smithsonian Environmental Research Center, MD
- Smithsonian Marine Station at Fort Pierce, FL
- Caribbean Coral Reef Ecosystems Program, Belize
- Smithsonian Tropical Research Institute, Panama

Smithsonian Scientific Diving Program

Approximately 100 Divers logging 3300 dives per year

2018 Dive Locations

Alaska, Bahamas, Belize, Bonaire, California, Canada, Cayman Islands, Chesapeake Bay, Curacao, Florida, Guam, Hawaii, Maldives, Maryland, Mexico, Mo'orea, New Caledonia, Panama, Texas, Virginia

Smithsonian Scientific Diving Program

- Purpose

To learn about how to identify and mitigate hazards to protect our divers.

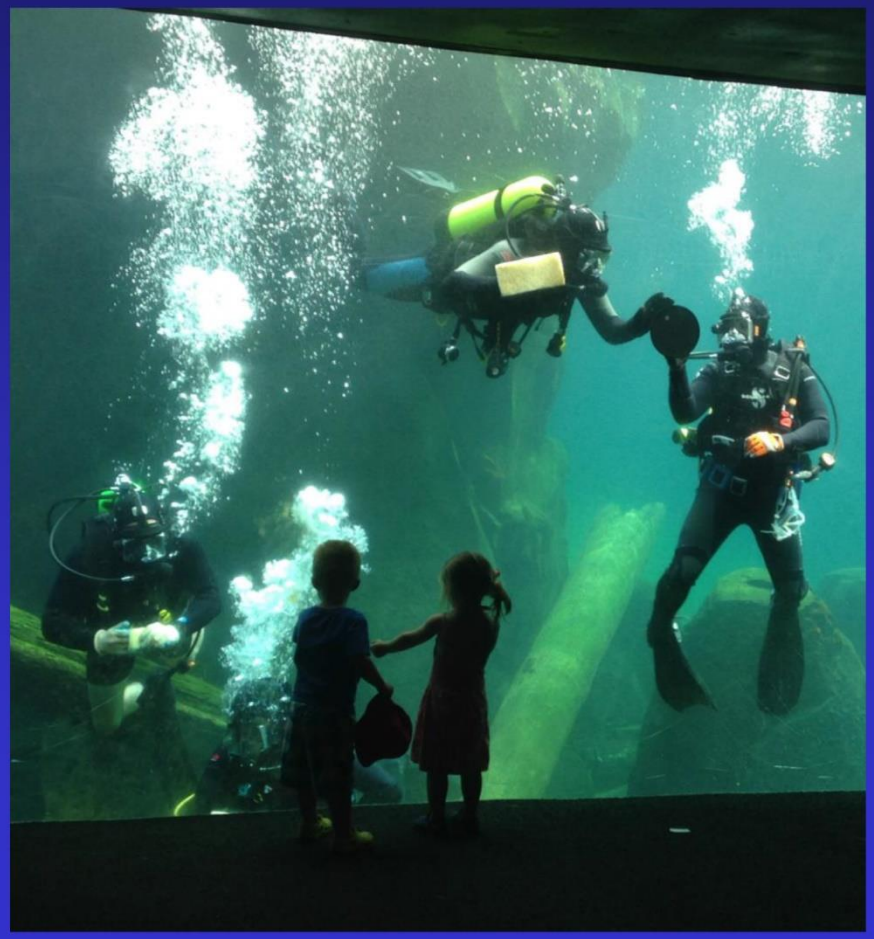
- Concerns
  - National Zoological Park
  - Invasive Species
  - Chesapeake Bay
  - Foreign locations

Smithsonian Scientific Diving Program

National Zoological Park

Seal and Sea Lion Pool

- Tasks
  - Cleaning glass
  - Vacuuming animal waste
- Concerns
  - Pathogens
- Mitigation
  - FFM

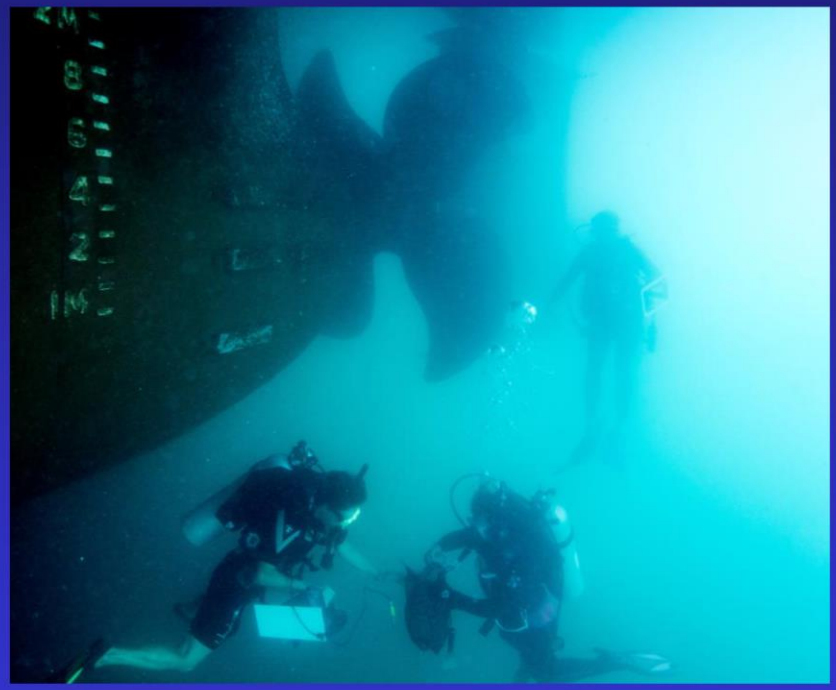


Smithsonian Scientific Diving Program

Invasive Species

Ship hull sampling in highly trafficked harbors

- Tasks
  - Sampling and photographing ship hulls
- Concerns
  - Industrial contaminates
- Mitigation
  - None

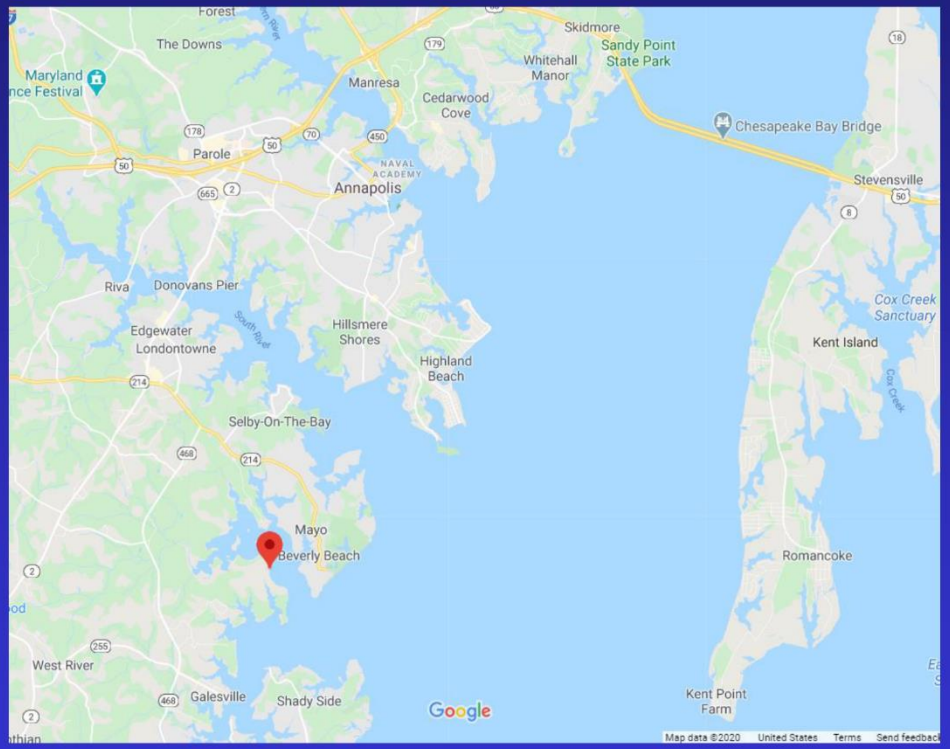


Smithsonian Scientific Diving Program

Chesapeake Bay

Oyster surveys

- Tasks
  - Benthic sampling
- Concerns
  - Pathogens
  - Toxins
- Mitigation
  - None



Smithsonian Scientific Diving Program

Foreign locations

Minimal or no regulations

- Tasks
  - Collecting, surveys
- Concerns
  - Pathogens
  - Toxins
  - Industrial contaminants and hazards
- Mitigation
  - None

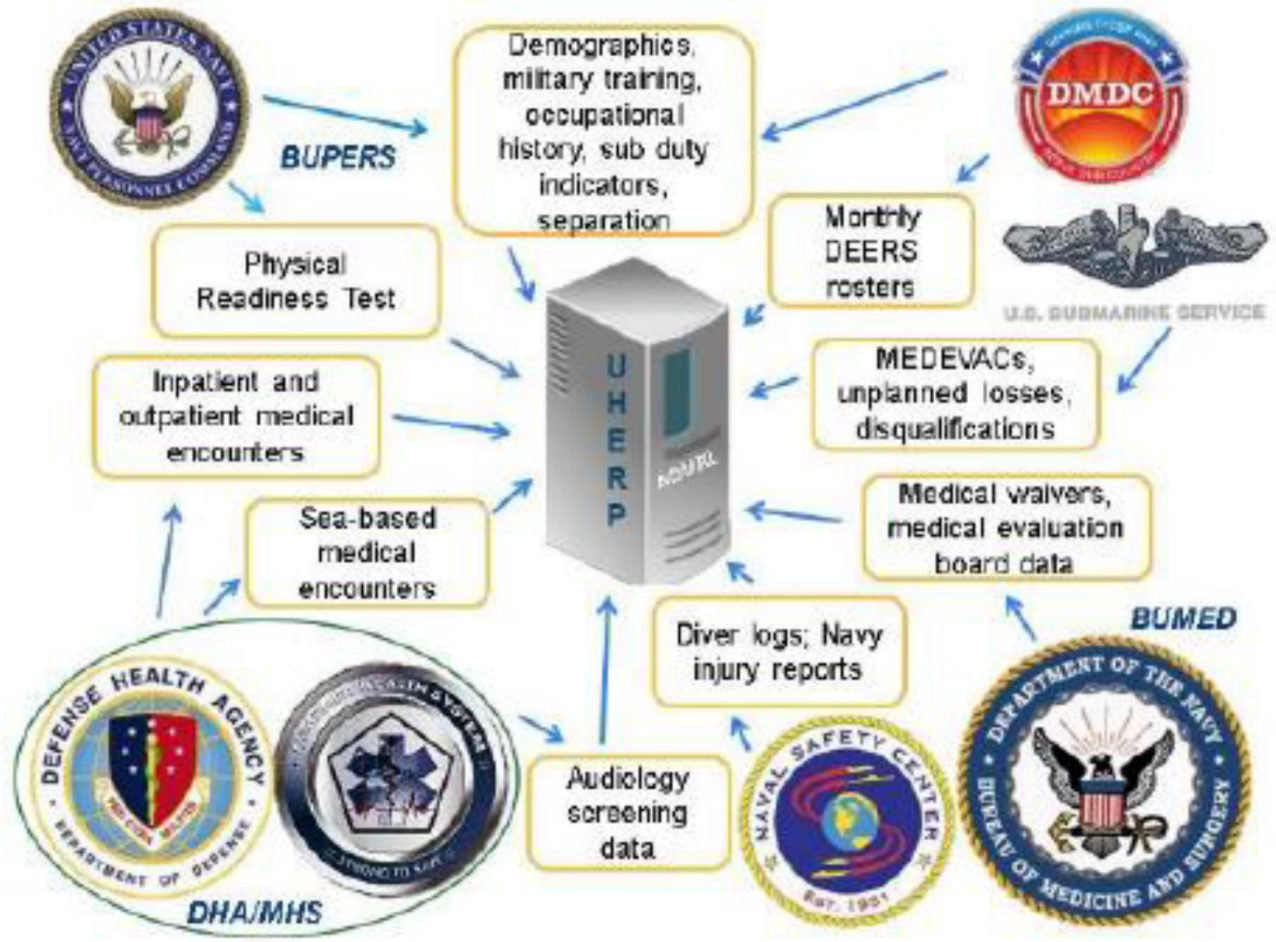
Smithsonian Scientific Diving Program

Thank you for allowing me to observe and learn!

Diver Health and Epidemiology Program (DHEP)

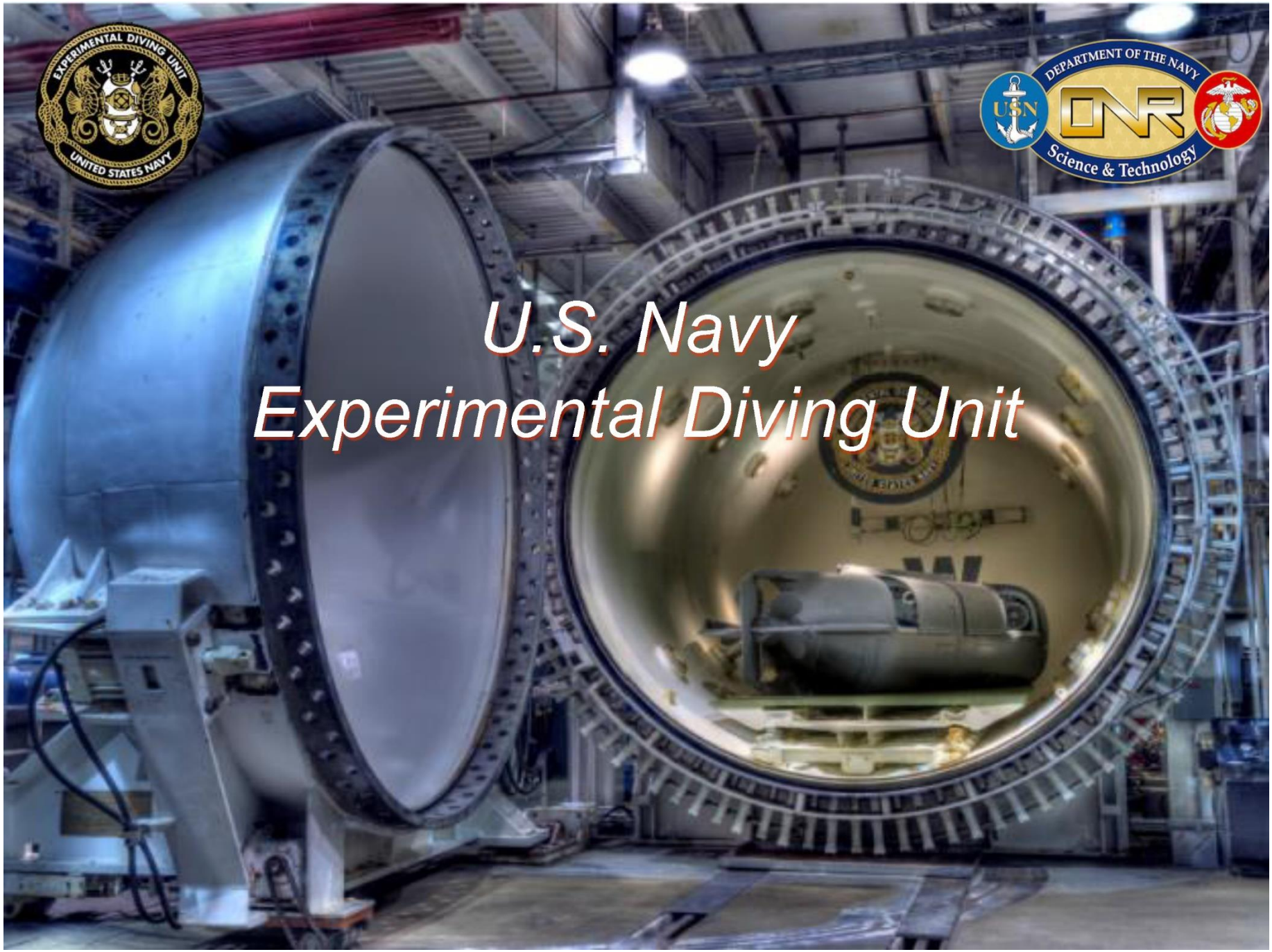
CDR Doug McAdams, MC(UMO/DMO), USN

- Purpose: Design and Methods (by year): Conduct a longitudinal, population-based health study of approximately 10,000 U.S. Navy divers.
- Year 1: NSMRL will build Navy diver database by linking additional DoD databases to Undersea Health Epidemiology Research Program (UHERP) database.
- Year 2: Perform subject linkages across databases to assess and compare injury rates and location-specific medical issues for comparison with divers and non-divers.
- Year 3: Document the full spectrum of injuries and illnesses among these divers over a ten-year period from 2008 to 2018.


BUPERS
Demographics, military training, occupational history, sub duty indicators, separation
DMDC
Monthly DEERS rosters
U.S. SUBMARINE SERVICE
Physical Readiness Test
Inpatient and outpatient medical encounters
Sea-based medical encounters
UHERP
MEDEVACs, unplanned losses, disqualifications
Medical waivers, medical evaluation board data
Diver logs; Navy injury reports
BUMED
DEFENSE HEALTH AGENCY
DEPARTMENT OF DEFENSE
DHA/MHS
Audiology screening data
NAVAL SAFETY CENTER
DEPARTMENT OF THE NAVY
BUREAU OF MEDICINE AND SURGERY

Main Reports

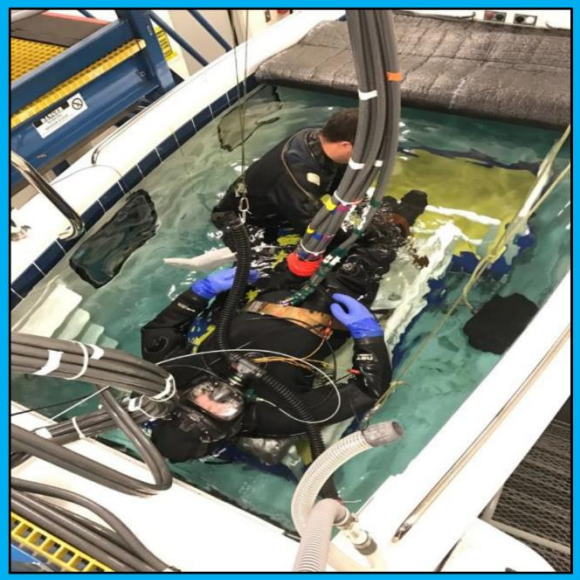
- The risks by dive location and identify any increased prevalence of conditions (mainly skin and pulmonary) where there is concern for contaminated waters.
- The full spectrum of injuries and illnesses among current and recently separated Navy divers over a ten-year period.

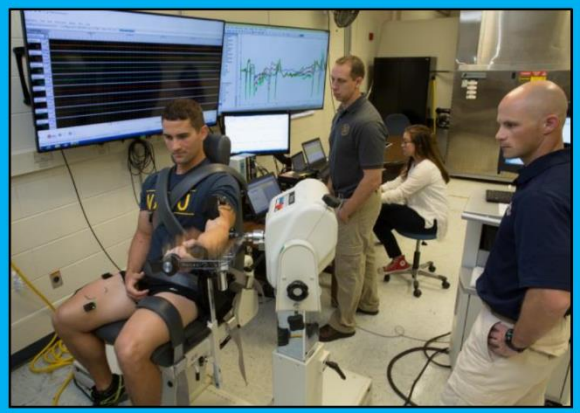

EXPERIMENTAL DIVING UNIT
UNITED STATES NAVY
DEPARTMENT OF THE NAVY
USN
ONR
Science & Technology
U.S. Navy
Experimental Diving Unit

Navy Experimental Diving Unit

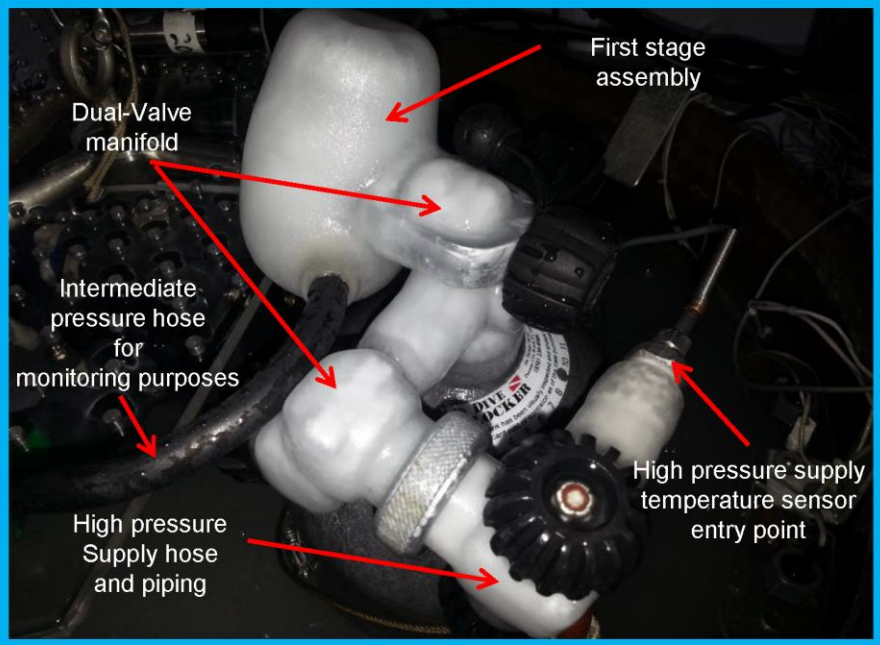
Biomedical Research and Development

- Biomedical Instrumentation Design and Development
- **Contaminated Water Diving Procedures and Guidance**
- Decompression Algorithm and Table Development
- Development of Procedures for Treating DCS
- Environmental Stress Evaluation and Guidance
- Gas Analysis Methods and Procedures
- Human Performance Testing (Thermal/Hyperbaric)
- Oxygen Toxicity Risk Assessment
- Respiratory Mechanics Evaluation and Guidance





Navy Experimental Diving Unit
Testing & Evaluation
for
Authorized for Navy Use (ANU) Listing

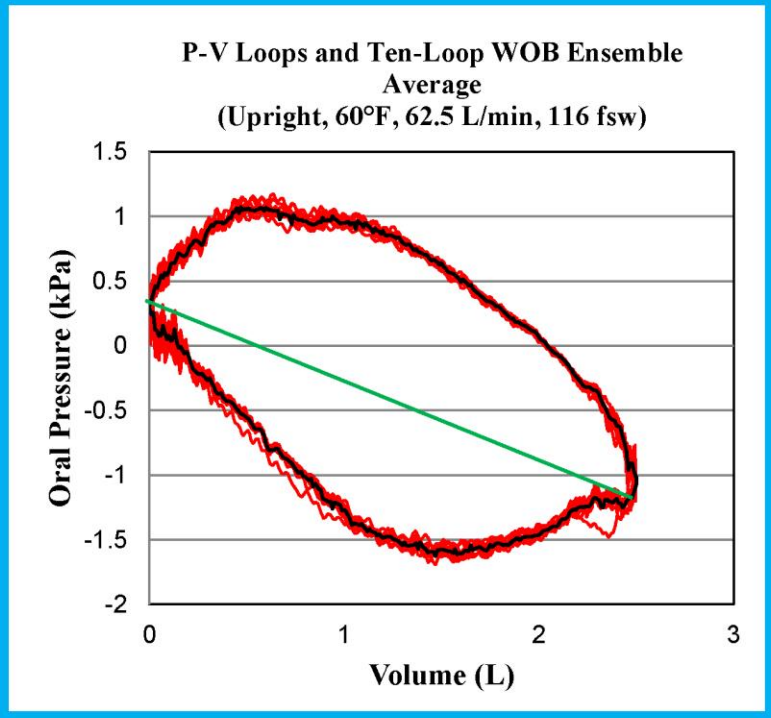


Freezing Water Performance

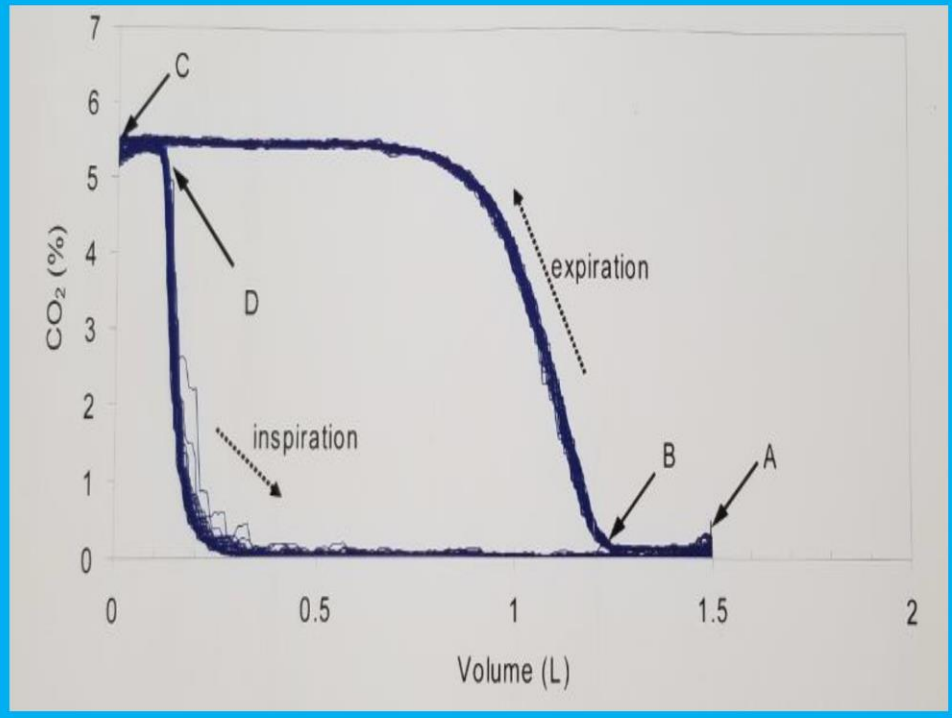
UBA Performance & Capabilities

Experimental Diving Unit

Unmanned Testing & Evaluation



Work of Breathing & Resistive Effort



CO_2 Retention (Helmet Washout)

Experimental Diving Unit

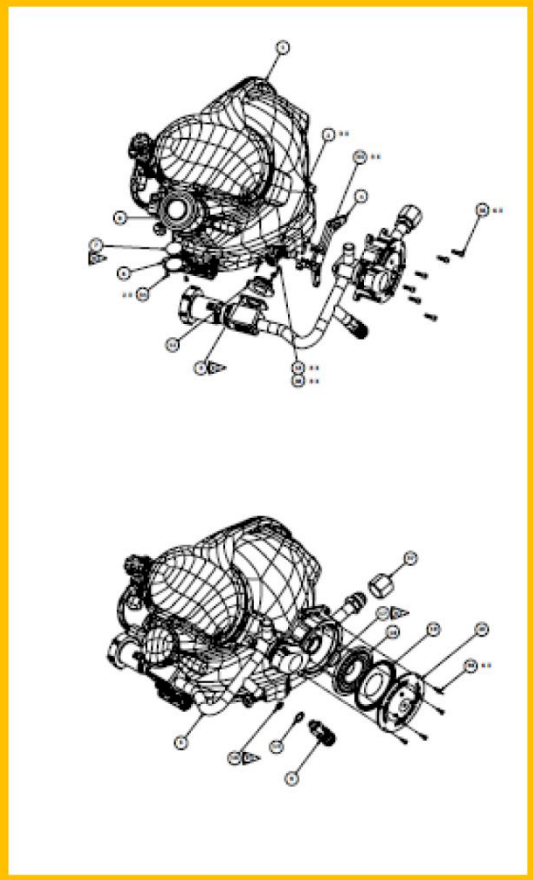
Manned Testing & Evaluation

Contaminated Water
Intrusion Detection
(Fluorescein Dye)

Form-Fit-Function Dives

Navy Experimental Diving Unit

T&E of Specialized Equipment for Contaminated Water Diving



Exhaust Gas Recovery

Surface-Supplied
with
Surface-Exhaust (Recovery)

Navy Experimental Diving Unit

Diving Incident Investigations

U.S. Military Commands

Federal, State & Regional Government Agencies

Public Service
Law Enforcement
Medical Examiners

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Contaminated Water Diving Information

Questions ?

Questions ?

vincent.ferris@navy.mil

https://www.facebook.com/navxdivu (NEDU)

Bio ID: Real-time, portable pathogen detection system

For Public Release

Larry Dugan, PhD.
November 1, 2019

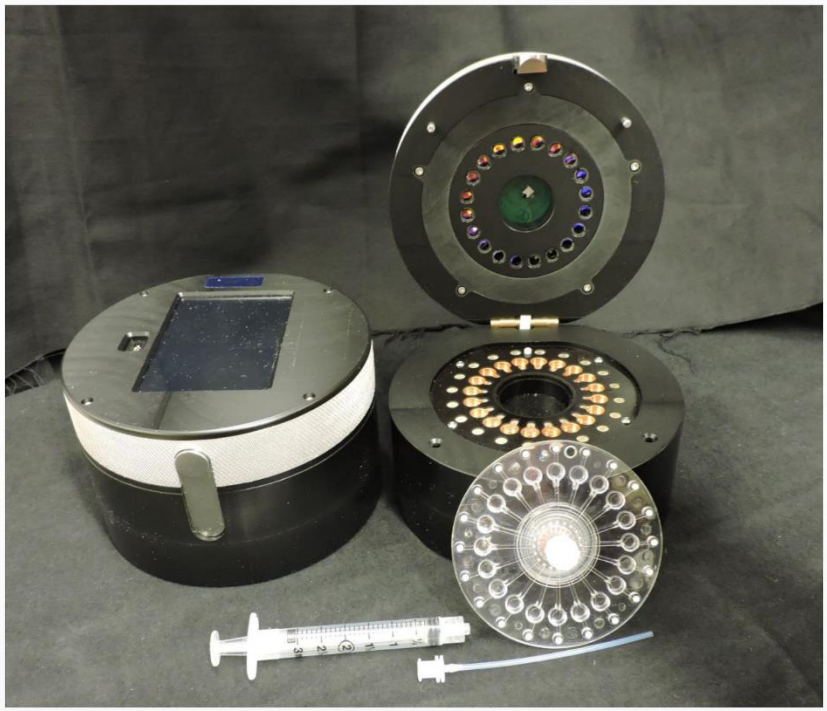
LLNL-PRES-797061

This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under contract DE-AC52-07NA27344. Lawrence Livermore National Security, LLC

Lawrence Livermore National Laboratory

Rapid, easy-to-use, portable pathogen detection system

- Our multidisciplinary team has developed a portable pathogen detection system capable of identifying up to 18 pathogens in 30 minutes
- One-step sample loading, isothermal heating, optical detection, 2-year reagent stability, USB/Bluetooth
- Compact size: 5” dia. x 3” ht x 3 lbs



We are expanding from our initial assay panel

	Primary assay panel targets	Additional assays available	Assays under development
Bacteria	*B. anthracis, Y. pestis, F. tularensis, S. aureus, Brucella* spp., *B. thuringiensis* (Training surrogate)	*E. coli, P. aeruginosa, S. typhimurium*	*A. hydrophila, L. pneumophila, V. cholera, V. vulnificis, S. dysenteriae, K. pneumoniae, L. monocytogenes*
Toxin gene DNA	Botulinum toxins Type A & B, Ricin		
Viruses	Variola major, V. minor	Foot and mouth disease virus (FMDv)	Hepatitis A, Hepatitis E, Enteroviruses
Antimicrobial resistance markers		Beta-lactamase, mecA	
Parasites			*C. parvum, G. lamblia, E. histolytica, I. belli, I. hominus*

We are transitioning to on cartridge direct detection of live pathogens

Pathogen	Strains tested	Matrix	Lowest DNA detected[1], fg/rxn	Lowest detected cell concentration to date, CFU/ml		
				Wet assay Commercial instrument[2]	Dry assay Commercial instrument[2]	Dry assay Cartridge system[3]
Bacillus anthracis	Sterne UT238, AO462	Water	500	$6x10^3$	$7x10^4$	$3x10^7$
Yersinia pestis	CO92 pgm-	Water	5000	NT	NT	NT
Francisella tularensis	SchuS4, LVS	Water	500	NT	NT	NT
Pan-*Brucella* spp.	C68	Water	500	NT	NT	NT
Botulinum toxin A	438	Water	500	NT	NT	NT
Botulinum toxin B	439, 51386	Water	500	NT	NT	NT
Variola	K4L.2ST Fragment	Water	5	NT	NT	NT
Escherichia coli	TY2482	Water	500	$2x10^5$	$2x10^6$	NT
Staphylococcus aureus	NRS54	Marine Water	500	$3x10^5$	$1x10^8$	$4x10^8$
Salmonella typhimurium	LT2	Water	NT	$2x10^5$	NT	NT
Pseudomonas aeruginosa	PAO1	Water	500	NT	NT	NT

Standard reaction for wet assay evaluation contains 1 ng DNA, NT = Not Tested, CFU = colony forming units
[1]DNA detection based on 25 ul wet assay on commercial instrument
[2]5 ul cell culture resuspended in water diluted to 25 ul final volume for commercial instrument reaction
[3]30 ul cell culture resuspended in water diluted to 3000 ul final volume for cartridge system, 90 ul/reaction

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The Contamination Risk for Underwater Divers (CRUD) Workshop was convened by the Office of Naval Research (ONR) and Naval Information Warfare Center Pacific (NIWC Pacific) to facilitate an open forum and dialogue between contaminated water diving (CWD) community stakeholders, for purposes of discussing diving concerns related to aquatic environmental contamination, which can be characterized within a risk framework. The workshop was focused on the identification and evaluation of critical aspects of chemical and biological hazards at dive sites that may drive potential risk associated with diving in contaminated water. Particular emphasis was placed on the sharing of known impacts, potential challenges and solutions, and experiences, including lessons learned, that might lead to synergies amongst CWD stakeholders going forward. The workshop initially focused on developing a problem statement from a high-level perspective that would serve as a starting point from which discussion by participants would commence in order to identify and incorporate important aspects that were necessary for consensus-building.
As part of this initial problem definition effort, high level presentations were provided. These included a services perspective, a summary of the state of the science, and an overview of conventional risk-based approaches that either had been used previously or could potentially be used as a starting point for understanding and assessing CWD in a risk-based framework. These presentations and related discussions were followed throughout the remainder of the workshop by thoughts, experiences, and challenges related to CWD risk characterization, that were considered important to each of the stakeholder organizations. This set the stage and provided a backdrop for building a consensus regarding the inherent complexities of diving in contaminated water sites; what is known about CWD-related issues, in addition to what is not known, or gaps that exist in our understanding of those issues; what data might already be available, and correspondingly, what data gaps exist; followed ultimately by discussions regarding how to go about developing solutions and approaches in response to the challenges identified. The following proceedings capture the details of topics and related free-flowing discussions as they occurred in real time, and in an appropriate level of detail, with the goal of providing the reader with a sense of current issues that are germane to CWD risk.

15. SUBJECT TERMS

Contamination; contaminated water diving; risk assessment; site characterization; workshop; challenges; solutions; diversterm

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