

Human Capital and Technical Workforce

August 8-9, 2017

U.S. Naval Observatory

Washington, DC

**U.S. NAVY TASK FORCE OCEAN
2017 SUMMER WORKSHOP SERIES**

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Background

Task Force Ocean was established on March 13, 2017, under the direction of the Chief of Naval Operations and led by the Oceanographer of the Navy, Director of Task Force Ocean. The goal of Task Force Ocean is to advance ocean science in the United States and ensure that the U.S. Navy maintains a competitive advantage in its ability to understand and exploit the ocean environment. The Task Force will assess the state of Navy-relevant ocean sciences in the U.S. and the Navy's capacity and capability to exploit new science and technology in this arena.

The Task Force charter, signed July 5, 2017, established five working groups focused on relevant aspects of its mission: 1) Sensing and Observations; 2) Understanding, Modeling and Prediction, 3) Naval Applications and Decision Aids, 4) Human Capital and Technical Workforce, and 5) Strategic Communications. These working groups are tasked with engaging federal interagency stakeholders as well as subject matter experts in government, academia and industry to develop a plan to remain ahead of our competitors in three areas: 1) Navy-relevant ocean science infrastructure, 2) the U.S. Navy's capability and capacity to understand and exploit knowledge of the ocean environment , and 3) the U.S. Navy's capability and capacity to leverage the full range of science and technology development in ocean sciences through successful transitions to operations.

The first four working groups listed above held workshops during August and September of 2017 to identify the key objectives in each focus area, actionable tasks for each objective and identify associated stakeholders and subject matter experts throughout the U.S. ocean science enterprise. This report provides a summary of the first of these workshops—Human Capital and Technical Workforce—co-chaired by Dr. Ruth Preller and Dr. Doug Todoroff of the Naval Research Laboratory.

Executive Summary

The Human Capital and Technical Workforce workshop took place on August 8-9 at the U.S. Navy Observatory. Approximately 30 experts from the Navy, academia and educational societies attended this workshop to identify and discuss workforce issues related to Task Force Ocean and then identified some near, mid, and long-term actions that will directly support the charter of the Task Force. To help resolve our Navy's current and projected workforce challenges, key observations and recommendations are provided in this executive summary while additional details are provided in the body of this report.

Key Observations:

To accurately determine the size of and technical skills required for the Navy's oceanography workforce through the next decade, requirements and mission needs must be identified in advance. If future Navy mission needs will require additional ships and platforms and/or take place in regions where communications are limited, these factors will impact the size and training required for the workforce.

Examples of current techniques used to determine the size of the required workforce were discussed. One such example, Naval Sea Systems Command's Long Term Research and Development Identification Plan (LRRDP) was considered to be a very useful model. The LRRDP is based on identifying the requirement, determining the technology needed to meet the requirement and determining if that expertise exists internally or must be cultivated or obtained externally (universities or industry).

There has been a downward trend in the size of the Naval Research and Development Enterprise in the fields of acoustics and oceanography over the past two decades. The working group believed that a workforce of this size will not be adequate to meet future Navy requirements. Many factors contributed to this downward trend including availability of people with the required skills and the lack of incentive for students to specialize in the field of oceanography when career paths in this field are limited (unlike engineering).

In the past, the U.S. owned the talent and technologies that gave us a lead in ocean sciences and its application to Naval operations. Today, technology is a commodity that is available to more nations and the U.S. must increase its technical talent to rise above a leveling technology field.

The consensus of the working group was that the U.S. academic institutions are still the best place in the world to learn about Ocean Science and Ocean Acoustics, however the U.S. is no longer perceived as the place of career opportunity for these areas. In the past, foreign students came to the U.S. to be educated in these areas and generally stayed after graduation, obtaining a green card and/or citizenship and became part of the ocean science/ocean acoustics workforce. Today, foreign students still come to the U.S. to be educated, but upon graduation the vast majority return home where there are more opportunities in these areas.

To build the Oceanography technical workforce of the future decade, young scientists must be motivated to work in the oceanography and acoustics fields. One way to do this is to identify some Grand Challenge Problems or Noble Goals that are of vital importance to the Navy and are interesting

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enough science problems to entice young scientists to work on them during their careers. Another way is to ensure long-term consistent funding. Spurt-like funding is not a useful way to successfully advance basic research. Lack of funding impacts the Navy's ability to recruit and, to recruit the best and brightest. An alert graduate student who does not see a sure funded future in a particular field will look for another.

The Navy established the concept of National Naval Responsibilities (NNR) in the early 2000's as science and engineering topics of little interest to other services or Agencies but of high interest to the Navy. Ocean acoustics is one of the NNRs but no other area of Oceanography has been so designated. Such a designation might focus funds and technology to this area as well as skilled scientists.

The 2020-2030 college/graduate student is currently in elementary or middle school. Therefore, it is important to increase the students' awareness of oceanography fields at a relatively young age to build the oceanographic work force of the future. In addition, diversity is an important characteristic of a healthy workforce and should be considered when building the future workforce.

An important factor for generating the most highly skilled workforce and for getting the best technology from academia to the Navy is to be sure that research scientists and their students are aware of Navy technology needs. To develop new and advance existing technologies for Navy application, the science community must understand the problems the Navy has to solve as well as the operational restrictions the Navy must live with. In recent years, however, the ocean science community's awareness of the Navy's need for the application of ocean sciences has been greatly reduced. In the past, the academic community often became aware of Navy applications through conference presentations and topic specific workshops. However, conference attendance by Navy personnel was restricted during the past several years and topic specific workshops are no longer or at best, sporadically held. The science community's interaction with the operational Navy must increase in the coming decade to make sure that advances in science and technology can be focused on Navy need. Developing strong and continuous relationships between the Navy and universities in the past, resulted in successful recruiting of researchers into those partnering Navy labs and warfare centers

To strengthen the operational oceanography workforce of the future, the Navy must expand advanced education for Navy personnel in the ocean sciences. The Navy needs to look beyond the traditional training opportunities and be open to new ideas that will allow an Officer to advance his education by taking courses toward his degree at different institutions during his career. This also has the advantage of exposing him to different viewpoints during his education. Further exploration of new certificate programs might provide additional, focused training for the highly mobile sailor.

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Recommended Actions / Way Forward

The following is a list of key recommended actions from the Human Capital and Technical Workforce Working group. Additional recommendations are provided in the body of this report.

1. Navy requirements should be defined in advance to determine the size and technical expertise needed to meet these requirements in 2020-2030.
 - The Fleet of 2020-2030 will need to maintain both a strong reach back capability while providing more highly trained onboard Navy personnel.
 - The Navy should carefully examine, based on advances in ocean sensing and modeling technology, the level of expertise needed on board ship to meet mission requirements.
2. Improve the Ocean Science Community's awareness of Navy requirements/technical needs by
 - Reinvigorate workshops and meetings between the science community and the Navy like the Tactical Ocean Symposia or specific topic-related workshops like the Ocean Prediction Workshop.
 - Create Scientist- to-Land-based Center programs including: scientists visits to operational centers (weeks to a year stay), summer faculty and graduate students working at labs.
 - Create an Oceanography Chair at key locations such as Stennis Space Center.
 - Enhance scientist (or educator) to sea programs.
 - Develop programs at academic institutions for training in operational oceanography.
3. Investigate creating a new National Naval Responsibility (NNR) for Oceanography.
 - Ensure robust funding that spans 6.1-6.4 for the existing Ocean Acoustics NNR.
4. Define Grand Challenges or Nobel Goals related to Oceanography and Acoustics.
5. The Navy needs to ensure that the necessary funding is available to educate and hire the workforce needed to meet its requirements through the next decade.
 - Basic research needs to be funded consistently and long term. This generates the best ideas and allows recruitment of the best and brightest minds in the field.
 - STEM outreach in ocean sciences should be reinvigorated.
 - Ensure that Diversity is a part of the future workforce.

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6. Improve the skills and abilities of deployed and direct support (e.g. Naval Oceanographic Office) Navy personnel including the ability to adapt/invent in consultation with experts from across the R&D community.
 - Investigate the possibility of degrees for Navy personnel that can be obtained through university partnering (such as partnering of the Naval Postgraduate School (NPS) and other universities). This could include the establishment of Undersea Warfare (USW) / Meteorology and Oceanography civilian institutions programs at additional universities.
 - Develop new certification programs through which enlisted personnel can receive training and education in particular subject areas based on new technologies and Navy requirements.
7. To enhance recruiting, develop strong and continuous relationships between Navy labs/warfare centers and universities including summer programs, joint research funding, and student interaction (e.g., thesis topics) with Navy problems.

Stakeholders:

Stakeholders associated with these recommendations include both Navy and non-Navy agencies.

For the Navy agencies, the stakeholders include: OPNAV N2N6E, CNMOC, NAVIFOR, NAVSEA (NUWCs and NSWCs), NPS, USNA, NRL and ONR.

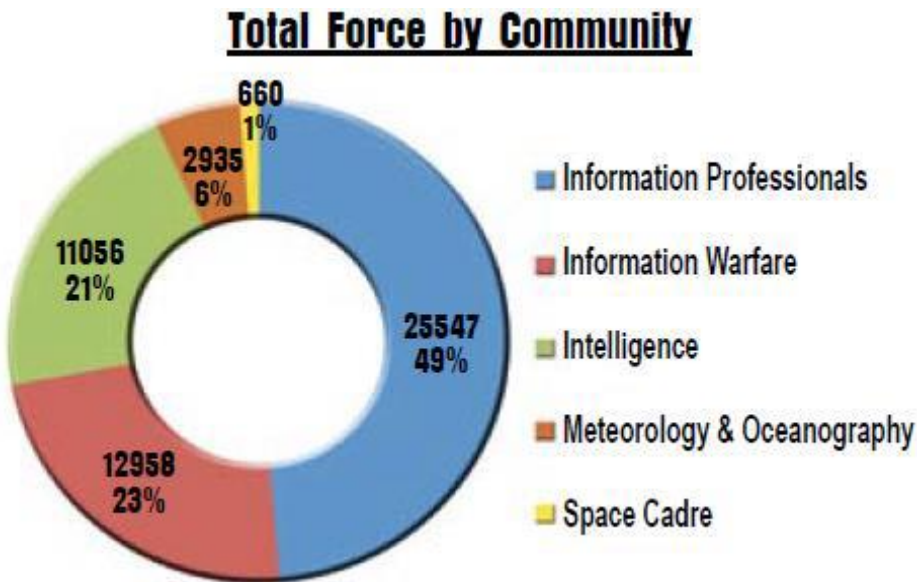
For the non-Navy agencies, the stakeholders include: NSF, NOAA, DOE, NASA, BOEM and DOI.

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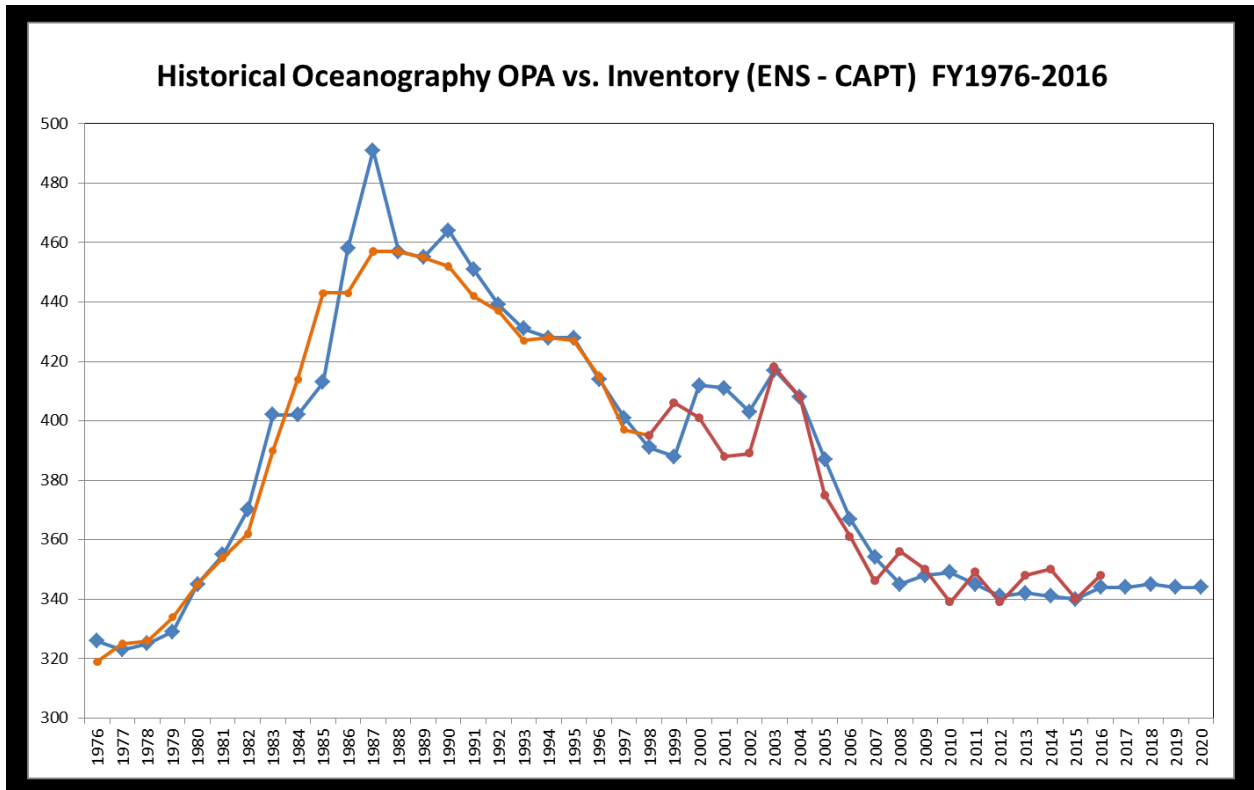
Session I: Future Capacity and Capability for U.S. Naval Oceanography Community

Overview: A presentation on the current capability of the U. S. Naval Oceanography Community was presented to the working group by Ms Megan Natter. Ms Natter’s presentation showed that the current Naval Operational Enterprise is made up of a combination of 2412 Civilian/Navy personnel/contractors (1203/981/201). The Naval Oceanographic office personnel is composed of 781 total (704/21/56); the Fleet Numerical Meteorology and Oceanography Center personnel is composed of 190 total (129/19/42) while the Fleet Survey Team personnel consists of 20 Civilians and 41 Navy. The U.S. Naval Observatory has a total of 157 personnel (127/8/22). The Naval Oceanography Operations Command has 399 total personnel (71/327/1); the Naval Meteorology and Oceanography Professional Development Center has 62 total personnel consisting of 25 Civilians and 37 Navy. Fleet Weather Center in Norfolk has 333 total personnel (50/234/49) while the Fleet Weather Center in San Diego has a total of 306 personnel (33/234/29).

The Meteorology and Oceanography (METOC) Community is now part of the Informational Warfare Community making up approximately 23% of that community.



How does today’s manpower level compare with those of past years? This historical manpower chart shows the buildup of manpower in the 1980s, the large drawdown in the 1990s with a slight bump following September 11, 2001, and then a decline to today. In terms of Officer Program Authorization (OPA)—Congressional allocation of Officers, Naval Oceanography is at 1980 levels with approximately 350 METOC Officers Navy-wide including approximately 200 in METOC-specific commands.



Observations:

Is a workforce the equivalent of that from the 1980s adequate to meet the needs of 2020 or 2030?

The Navy sees itself focusing on four main efforts now and in the future: 1) strengthening Naval power at and from the Sea, 2) achieving high velocity learning at every level, 3) strengthening the diverse mix (active duty and reservist sailors and civilians) that defines the Navy team; and 4) expanding our network of partners. To be successful in these efforts will require an increase in manpower for 2020 as suggested in the following table by requirement area.

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Requirements Area	% Increase Required in Manpower (2020)
Electromagnetic Warfare	45%
Mine Warfare	38%
Safety of Flight/Navigation	27%
Multi-warfare and safety (Direct Support)	24%
Unmanned Vehicles	12%
Anti-submarine warfare	12%
Maritime/Aviation Safety & RP (Reachback)	11%
Command Support	
Command Support	19%
Training and Readiness	
Training and Readiness	13%
IT	
IT	20%
Additional T-AGS Platforms (+1)	
Additional T-AGS Platforms (+1)	16%

The Navy also anticipates the addition of more ships (platforms) which could require a larger workforce. This may require an increase in manpower of up to 23% to meet the requirements of the new ships. Other possibilities include: 1) Keeping the same number of people but assuring that they are more highly and broadly trained, or 2) automating more so that the size of the workforce does not have to greatly increase in addition to increased training of the existing workforce.

The Navy of the future is preparing more decentralized operations which will require having highly trained personal on board ship who would not have to rely on the expertise of those at the reach back cells.

Currently the bulk of METOC Officers have a master’s or doctoral degree. METOC is a restricted line community, so those with degrees are often experts in theory rather the practice. Sailors in general are more educated now, but most are not seeking METOC degrees. The civilians working at commands like the Naval Oceanographic Office and the Fleet Numerical Meteorology and Oceanography Center (the operational reachback centers) have advanced degrees—approximately 80%. Most of the METOC expertise exists in the civilian community.

Recommendations:

1. The size of the workforce of the 2020s should increase to meet future Naval requirements including adequately manning new ships.

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How much the workforce will need to increase depends on a) the requirements, b) the technical advances in automation and c) the education provided/available to the operational workforce to meet the needs generated by these requirements.

2. The Navy should move away from the “broad” training concept to a “T-shaped” training concept.

The broad training concept does not support specialized expertise. “T” shaped training can be somewhat broad but with at least one particular “depth” topic or field. This means that the Navy should not discourage specialization. If Navy personnel cannot specialize, then the future will have to count more and more on the civilian workforce to be their experts.

If the Fleet of 2020-2030 will need more acoustic and environmental information on board, then

3. They will need to maintain a strong reach back capability in addition to having more highly trained onboard Navy personnel.

The trained personnel should be able to use available reach back information, along with the local data, and the onboard Tactical Decision Aids to generate the best guess information in a denied contact situation. An example of this could be that in 2030, reach back would provide a much longer term (16-30 days) forecast of the environment to the ship. That long-term forecast could extend to “denied” time periods and be used in conjunction with local data to provide the best guess of the local environment by a trained, onboard METOC Officer.

Session II: Assess Workforce Levels for Naval Research and Development Enterprise focusing on Ocean sciences and Acoustics.

Overview: In order to answer the questions 1) What key issues define/limit the workforce size?; 2) How does the workforce size today compare to that of past decades?; 3) Can/will/should this change?; the working group was presented with two discussions: one from the Office of Naval Research’s Acoustics program and the second from NAVSEA on methods they have implemented to meet their technology needs

Observations:

There has been a downward trend in the size of the Naval Research and Development Enterprise over the past two decades. The size of the NRL workforce over the past two decades is shown below. Oceanography has been somewhat stable with a small, recent decline, while Acoustics has experienced a dramatic long-term negative trend.

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The overall Navy Research Workforce Trends are all downward. The Navy Oceanography Enterprise employee numbers from 2006-2016 for Physical Scientists and Oceanographers has dropped from 408 to 359 and the numbers for Physicists and Geophysicists has dropped from 42 to 22.

The Office of Naval Research's Acoustics program has several methods in place for building the future workforce in this field. To incentivize research careers in ocean acoustics, the 6.1 ONR ocean acoustics program has Special Research Awards in ocean acoustics including graduate traineeship awards, postdoctoral fellowships, entry-level faculty awards. For postdoctoral awards, special consideration is given to those applications that include collaboration with a Naval Research Laboratory or a Naval warfare center. There is also a preference for U.S. citizens. Non-U.S. citizens will obviously present a problem for both clearances and hiring into the federal workforce. A snapshot of acoustic graduate students showed that 49 out of 80 were U.S. citizens. However, these statistics also show that the total number of their funded graduate students has declined in recent years. Part of this decline is due to the increased cost of a graduate student. As for funded researchers, ONR feels that researchers who are in their program are very good because the competition is intense. Some good news for the education of Officers in the field of acoustics is that the MIT/WHOI program has been recently reinvigorated with an increase to a maximum of six students per year (from three). ADM Richardson, Chief of Naval Operations, has supported this program and the various warfare communities are encouraging increased line Officer participation (including submarine Officers) which has strengthened the program.

There are several different techniques the Navy uses for assessing the necessary workforce size and composition. NAVSEA shared some of their approaches to identifying the workforce that they need for the future. NAVSEA is a working capital fund organization whose mission is to engineer, build, buy and

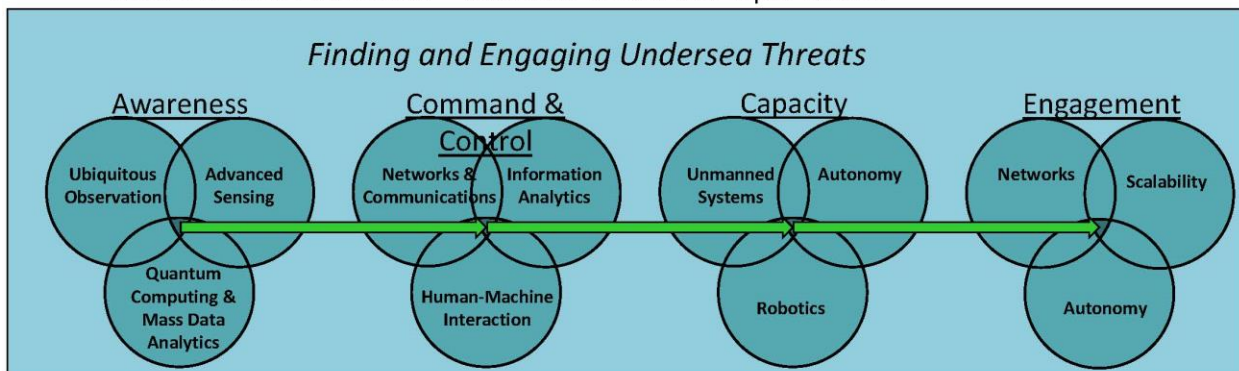
maintain ships, submarines and combat systems that meet the Fleet's current and future operational requirements. In order to plan for the right workforce, they identify a requirement or a mission and then determine what technology they will need to meet this requirement.

One of the tools that NAVSEA uses to plan for a workforce that has the right size is their Long Range Research and Development Plan (LRRDP). An example is given in the following figure:



LRRDP Technology Identification Approach

- No single technology is going to be the panacea for undersea operations
- Unique / atypical merging of select technologies – predominantly matured via commercial application – have intriguing possibilities
 - Require further analysis and evaluation
- One Mission Examined – Counter Undersea Operations



- Additional missions, threats and associated effects (i.e. problem statements) can be identified and used to create other “technology combinations” solution recommendations

NAVSEA translates the fleet needs into science and technology (S&T) questions and determines: What are the technology domains that will have to be used to meet these requirements? What are the next set of skills that they will need? Then they either develop the skill internally or connect with universities who have the expertise.

If you determine the skillset you need and the number of people needed to complete the tasks to successfully meet your goal, are those people available to hire? Is the available workforce diminishing? Furthermore, there is problem related to students who graduate with degrees in oceanography or acoustics. Unlike students graduating with a degree in engineering, options for oceanography and acoustic career paths are limited. They graduate, do a postdoc and then either get a job at a lab, a university or have to leave the field. Their opportunities in private industry are often limited. Salaries

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for these positions are not competitive. This drastically reduces their incentive to enter these fields ultimately reducing the size of the available workforce.

In addition, newly trained acousticians no longer are interested in doing traditional acoustics as posed to them today. To get new students into the workforce who are interested in naval acoustic problems, we have to provide them with problems that will interest them. We need to remember the importance of the field of acoustics to the Navy.

Another important issue to consider is whether we are looking for the people with the right level of skill? The number of Oceanographers may currently be stable at a PhD level, but is a PhD always required or can a master-level or bachelor-level education meet the need? Dial-up doctors can't replace the field doctors. They can warn us about some things, but they can't do surgery from afar. Depending on what is needed on a ship, there still may be a need for people on Naval ships who have a higher level of education and skill.

There has been a significant decrease in the number of U.S. citizens in the fields of oceanography and acoustics. As a whole, the U.S. is exporting our competitive advantage by way of foreign nationals who obtain advanced degrees in these fields in the U.S. and return to their native countries to work. Is there a way to keep some of this talent in the U.S? Although there has been much discussion on this topic, limitations exist on hiring foreign nationals into the Federal Government. Specifically, with respect to granting clearances, no solutions have been proposed other than special agreements through the Technology Cooperation Program (TTCP) or some easing of the current requirements. The solution to this problem requires further thought and thinking outside the box.

Recommendations:

In order to determine the size of the 2020-2030 workforce, the Navy needs to:

- 1) Establish oceanographic and acoustic requirements for this time period in order to plan for a workforce that is trained to meet those requirements. If these requirements are not made known far enough in advance, there may not be time to acquire and train the necessary workforce.
- 2) Hire the best and the brightest—those who can tackle new and diverse topics, leverage new technologies, and meet the needs of rapidly changing requirements.

Key issues defining and limiting workforce size were identified as: stable funding, rigors of getting technology to operations, salary, job location, students technical capabilities (e.g., numerics, mathematics, data analysis and assimilation, remote sensing), knowing the level of skill required, and U.S. citizenship required to work for federal government or military.

Recommendations to solve these problems include

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- Ensure the necessary funding is available to educate and hire the workforce necessary to meet the future Navy requirements.
- Program more stable funding.
- Know the skill level required to do the job.
- Support graduate school programs that address these necessary technical capabilities.
- Reduce the restriction on highly qualified foreign national hires where possible.

Acoustics has been designated a National Naval Responsibility but the size of the workforce in this field has been declining.

Recommendations include:

- 1) This NNR should have necessary and stable funding to meet the Navy requirements for 2020-2030.

Session III: Improve the U.S. Ocean Science Communities awareness of Naval Applications of Ocean Science and Technology

Overview: In order to improve the U.S Ocean Science Communities' awareness of Navy Applications of Ocean Science and Technology the working group first had to assess: 1) How is the Ocean Science Community currently made aware of Naval Applications?; and 2) Does the Ocean Science Community have a good understanding of the process of getting from basic research to operations? If not how can we improve it?

Observations: Methods by which we make the U.S. Ocean Science Community aware of Navy needs and requirements have not been very extensive over the past few decades. The scientific community is currently made aware of Navy applications through Navy (Naval Oceanographic Office (NAVOCEANO), Naval Research Laboratory (NRL) and warfare centers) presentations at conferences, joint research efforts (i.e. Office of Naval Research ONR Departmental Research Initiatives—DRIs), request for proposals and broad agency announcements, meetings such as S&T Expos, National Defense Industrial Association meetings, specific topic conferences (i.e. Johns Hopkins submarine conference) and reviews like the Unmanned Systems Review (restricted but not classified).

In general the ocean science community has a very limited idea of what it takes to get technology from basic research to the warfighter. In addition, this community has a very limited understanding of how basic research is further developed and then applied to operational use.

The Science Community has to understand what problems the Navy needs to solve. They also need to know the operational restrictions the Navy must live with. Knowing these restrictions (e.g., information

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assurance (IA), computer restrictions, bandwidth restrictions, availability of operational assets, validation and verification limits), often discourages scientists from working with the Navy. There needs to be a reality check, from the start, about what the Navy needs and what is available and required to meet these needs.

It is important that the ocean acoustics community understands why the Navy needs certain information and wants to exploit it. They should functionally understand what that role is. As a previous example, when ADM Richardson, Chief of Naval Operations, was the Commander of U.S. Submarine Forces, he outlined a vision of six needs required for advances in submarines in terms of capabilities (classified). That stuck and the importance of those needs still exists.

Recommendations:

1. Reinvigorate workshops and meetings that worked very well in the past.

Examples include: the Tactical Ocean Symposia (every few years, three days, targeted, reached a lot of people); or targeted workshops like the Ocean Modeling Workshops (from the 1980s) which consisted of three meetings (two large, one small) that included scientists from Harvard, Naval Postgraduate School, NRL, NAVOCEANO and a Navy flag-level representative (Admiral Cressy). Those workshops defined key science problems and technical issues that had to be addressed so that the Navy would be able to forecast the ocean in the next 10-20 years. Those issues included developing models that had high enough horizontal and vertical resolution to resolved eddies and vertical thermodynamics (impact acoustics); having real time global ocean observations of at least sea surface height and sea surface temperature and how to assimilate these observations into models; and having access to enough computational resources (High Performance Computing Centers).

These workshops should avoid being an exchange of command briefings and strategic plans and technical papers. They should be forums where Navy requirements are stated and a broad range of scientists (inside and outside of the Navy) challenge normal tactical procedures and criticize operation support information and its delivery. They should also include experts from different fields so different opinions can be expressed.

2. Ensure funding is available for joint meetings and symposia as well as the resultant work.
3. Increase the number of forums like the NAVOCEANO's two-day poster session describing their ongoing work.

For this year's NAVOCEANO Poster session, one day was devoted to unclassified posters and open to all interested parties. That forum should be better advertised to the Ocean Science Community and perhaps expanded to two days of unclassified posters. Recommend a one-to-two day session every two years or a one-day session each year. There could also be a restricted classified session. Warfare centers could do something similar.

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4. Have reviews like the autonomous vehicles review for other areas of Navy priority (modeling, remotely sensed observations).
5. Expand the Scientist-to-Sea program.

Scientists have to have in-person or hands-on experience of what the operational centers need and what their restrictions are (IT restrictions, metrics, requirements). How do we do this?

Recommendations

1. Create Scientists-to-Land-based Center programs. Have a research scientist visit an operational facility for anywhere from several weeks to a year.
2. Personnel exchanges. Conduct summer exchanges of faculty at labs and graduate students working in labs (generates early contact vs senior scientists).
3. Continue to fund and expand highly successful programs like the ONR Naval Research Enterprise Intern Program (NREIP) program and various visiting summer faculty programs.
4. Continue to fund and expand STEM programs including the Science and Engineering Apprentice Program (SEAP). Young people should have early contact with junior scientists as well as senior scientists.
5. Develop problem sets or real-world applications of data collected by the Navy for use in undergraduate classrooms to expose students to the data and understand potential military/tactical applications of the data sets.
6. Create an Oceanography Chair position co-located with operational centers.

Examples: A permanent rotating chair at Stennis Space Center (with NRL/NAVOCEANO). A previous successful example was the ONR funded Arctic chair at NPS, where the best scientists in that field were recruited to come and spend a year talking with the faculty and students and Officers.

How long do these exchanges need to be to be productive? A few weeks would benefit scientists, but for exchange to go both ways, the visit needs to be longer (a few months or more). A visitor could teach a short course. Even short visits have been productive (e.g., recent visits of Rutgers University researchers to NOAA for a one-month exchange).

7. Develop programs at universities for training operational oceanographers and integrate talks/seminars from active duty Oceanographers into these programs.

Examples: the University of Southern Mississippi (USM) certificate program in unmanned systems; a Rutgers proposal for an operational oceanography program.

8. Sabbaticals for federal laboratory and warfare center employees to go to industry, academia.

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Sending people to academia/industry is a good way to share knowledge between defense and industry sectors. Use groups like Marine Technology Society and the Consortium for Ocean Leadership to reach out to industry and academia to solicit participation.

Session IV: Strengthening the U.S. National scientific base in key scientific fields

Overview: To strengthen the U.S. National scientific base, we must get young scientists interested in oceanography. What could motivate 20-something undergraduates to get them into the field? How early do we need to start motivating students if the 2030 college/grad student is currently in junior high school?

The working group discussed the questions: what can we do to entice the next generation of scientists into the field? Can we define some of the next grand challenges (i.e., navy-relevant science problems, or Nobel Goals) for ocean science and acoustics?

The working group also discussed how we can improve diversity in these science fields and what can we do to tackle the problem of restricted hiring based on the ability to get a clearance.

Observations: We need to motivate the 20-somethings coming out of undergraduate school to go into the oceanography fields. One way to do this is to identify some grand challenge problems that are of vital importance to the Navy and are interesting enough science problems that young scientists will choose to work on them in their careers. This could reinvigorate their interest in the Navy as a place to spend their career. Students often want to be part of something bigger but they don't always know how. They need guidance and could be directed toward these "Noble Goals". Young scientists might also view work on these topics as providing them with options for other career paths in the future.

There is an educational challenge associated with creating a future workforce of oceanographers. To motivate students we need to create a new portfolio of training, education, and outreach across the full spectrum of students in order to increase ocean literacy and address complex Navy issues in oceanography and acoustics.

Several approaches were discussed to increase awareness and interest in Ocean Sciences through Education and Outreach focused on K – 12, undergraduate students, graduate students, enlisted Sailors, and Naval Officers. It was noted that, while the approaches and needs may be different at the different educational and target levels, the spectrum of education and outreach initiatives should be constructed to support engagement and retention throughout an educational pipeline. Given the time constraints of the exercise, the team members mainly explored issues relative to K – 12 students and enlisted Sailors. STEM investment is important to the overall concept of building the future METOC workforce. Leading STEM educators, as well as a robust body of research, indicates that STEM investment should begin at the elementary and middle school education levels. To specifically expand the 2020-2030 workforce, outreach efforts would have to focus on those students currently in middle school and high school.

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There must be assets available to meet these educational goals. Who are the stakeholders? ONR has a mission to fund STEM but the levels of funding are not increasing. NSF also funds STEM, but their funds are most likely not increasing. Other key stakeholders who should be interested in strengthening ocean scientific based should be: CNMOC (U.S. Naval Oceanography enterprise), N2N6E, NAVIFOR, NAVSEA (NUWCs and NSWCs), NPS, USNA, NRL and ONR.

To strengthen the oceanography workforce of the future, we must make sure that it is a diverse workforce. CNMOC showed us that the current gender diversity in the Oceanography (1800) part of the Navy is a ratio of 29%/71% of Women/Men. That ratio is higher than the overall Navy statistic of 18%/82%. Those numbers should be at least maintained, at best grown over the next decade along with other diverse groups.

Recommendations:

1. Investigate the possibility of creating new NNRs for Oceanography related fields.

In about 2002, the CNR established a concept called “National Naval Responsibilities (NNR).” The concept stands today. It recognizes that there are some science and engineering topics that are of little interest to other Services or Agencies, but of high relevance to the Navy and no one in America is making big profits by pursuing businesses in these fields. Naval Architecture/marine engineering is one NNR. Ocean Acoustics is another. Since the Navy’s mission is to operate in and on the ocean. Its mission is uniquely global. Maybe there should be other(s) NNRs: autonomous undersea navigation/autonomous vehicle communications, global, tactical scale oceanographic information? The NNR is a good concept and those defined NNR topics should be aggressively funded and their long term financial prospects should be recognized.

2. Define several Grand Challenge (Noble Goals) related to Oceanography and Acoustics.

Listed here are a few ideas put together in one afternoon. The Grand Challenge concept is a very important and time should be seriously devoted to defining these ideas by a group of consisting of both operational Navy and academics.

Three ideas were put forward as possible Grand Challenge topics.

2a. An Oceanography Challenge—Improved Ocean Forecasting

Create more accurate nowcasts and more accurate and longer-term forecasts of the ocean environment. Young scientists could relate to the idea of providing accurate ocean environmental information for the purpose of search and rescue, improved tropical cyclone prediction as well as some other non-Navy forecasts that impact marine recreation, fishing, etc.

With increasing computational capability and numerical techniques, models are capable of higher and higher resolution. Oceanographers need to understand what it is (what the processes are) that exists at these scales. Both Mesoscale (10-100 km) and Sub Mesoscale (100m – 10 km) ocean information is becoming available from our existing sensors and the

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possibility of an “ocean full of sensors” in the future. For numerical ocean models to produce information at these scales we need to understand ocean mesoscale and fine scale processes and features and how they impact the Navy relevant environment. Understanding these scales, how to model them and include (assimilate) observations at these scales should lead to an improvement in our ability to predict not only ocean currents, temperature and salinity but also ocean acoustics and ocean optics (impacted by biology and sediments).

The workforce required to meet this challenge would include:

- People with expertise in all of these areas related to improved ocean modeling and prediction;
- People who can run the sensors and interpret data, can quality control data, can run models, and can assess model results to determine if they are reasonable.
- People who understand how you operate adaptive sensors in the most advantageous way.
- People to drive the gliders, to support them, to pick them up if they go to the wrong place. Right now NAVO has 1 man for every 7 gliders used. So 1000 gliders would require an additional > 140 people. Either we need to have that many people or develop the technology to reduce that man/glider ratio (automation)

2b. An Observational Challenge---Can we create a 200 sq mile transparent section of the ocean? Who can make it the most transparent?

Take all commercial satellite, floats, in situ observations, observations from social media and other unconventional sources, and internet data and use it to create a 200 sq mile section of the transparent ocean. Anticipate new sources of data possible, ways to access all of this data and make it happen.

2c. An Acoustics Challenge ---Build a Coupled Ocean-atmosphere-acoustics-bottom prediction system incorporating through the sensor information.

There are several key components and attributes of such a system:

- The combination model and database will run continuously on board the supported platform (surface, subsurface, air) in order to take advantage of in situ environmental and other observations. The presence of ships for instance through AIS feeds would adjust the expected directional noise spectrum and once detected the ship signatures would not only influence the noise model, but through inversions provide inferences of ocean and bottom properties.
- The noise model itself is inherently multidimensional (location, angle of arrival, statistical characteristics, time of day, time of year, weather forecast, etc.). The understanding of the covariance between these components will support adjustments across the model based on limited in situ noise measurements and other updates (like weather observations and known ship tracks).

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- The background dynamic ocean model would also be routinely updated through data assimilation of in situ oceanographic and acoustic measurements. Similarly, the bottom model could be updated through measurements like the vertical distribution of ambient noise and differences between other signals captured by both direct path and bottom bounce.

To have a successful Grand Challenge effort, you have to have sufficient funds...it likely cannot be a zero sum game.

Continued Recommendations

3. Outreach to students 8-12 grades

a) Send military and civilian personnel to the schools to discuss Naval applications of ocean sciences and informing students of both military and civilian career paths in these fields while instilling a sense of service to their country.

b) Take advantage of high visibility days or events (e.g., World Ocean Day) to make a case for national level school participation in activities such as webinars or online activities that specifically highlight Naval applications.

c) STEM outreach needs to be reinvigorated and where possible, reinvigorated at the earliest possible opportunity including elementary and middle school where early robotic concepts and competitions should be encouraged.

4. Capitalize on diversity within U.S. national scientific base to create a strong workforce.

A number of recommendations were made for advancing and maintaining a diverse workforce. Several of these ideas are not actions that can be taken by TFO but are good recommendations and are included here for completeness.

- Ensure that diversity is included in K-12 for STEM promotion.
- Increase stem focused efforts on the inherent disadvantaged student to get them interested in ocean sciences at an early age and follow up by nurturing this interest over time.
- Ensure women are respected, listened to and treated as equals.
- Empower, encourage, women to speak and listen to them.
- Encourage Navy personnel (military and civilian) from diverse backgrounds to participate in education an outreach.
- Empower role models.

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- Increase interest in science using outreach by science giants with diversity (e.g., Neil deGrass Tyson).
- Expose a more diverse audience at a younger age. Come up with interesting forums like a summer ocean swimmer/oceanography camp.
- Provide more family friendly work place (like childcare at work).
- Reach out more directly to minority serving institutions.
- Build on programs tried at universities in the past that worked well.
- Collaborate with NOAA Education, Partnership Program.
- Work to address the “leaky pipeline” problem—keep under represented scientists in the field.
- Make sure mentoring programs are targeted at broader audiences.
- Support or require collaborative proposals that integrate top research universities with community colleges to overcome economic barriers to access.
- Increase research opportunities for a broader spectrum of undergraduates to support the BS and MS degree peak.
- Create better education opportunities for the inherently diverse sailor population to enable them to complete degrees in the ocean/acoustics fields.
- Identify and nurture gifted students of diverse backgrounds.
- Make sure EVERYONE is exposed to interesting national problems.
- Increased pay for math and science teachers in low performing schools.

Session V: Improving recruiting and retention efforts within the Navy’s technical workforce and Navy partner institutions

Overview: To determine how to improve recruiting and retention of the Navy’s technical workforce, the working group was asked: What are key things required to retain people in the ocean science field?; 2) How do we establish strong continuous relationships between the Navy and universities (partner institutions); 3) What type of programs can be developed to retain personnel?

Observations:

Long-time series consistency in funding is the best course for basic research. Steady growth would be better. But growth that is spurt-like or on a roller coaster is not useful. We want to hook the great minds and have them recruit the best graduate students to develop the best new knowledge. It is not

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assembly line production that can be sped up and then slowed down. Basic research draws from ideas from a brain that works at a steady pace.

Recruitment. Great principal investigators can lure talented graduate students to project teams. However, if the alert graduate student does not see a sure funded future in his field, he/she will find other careers to pursue in other industries such as financial, health care, IT, or business. Most of the aggressive scientists and engineers will pick a field in which they think they can make money or win proposals. If the Navy wants to make progress it must gradually and consistently grow basic research funding in the sub-fields it thinks most important. It needs new ideas and needs a cadre of scientists who are committed to a career of addressing Navy undersea challenges. ONR can and does work in many fields, but in some the Navy must steer the field, in others it rows along with others. In those where it steers, it should be easier to justify steady funding, in real terms, and make a decadal commitment.

Good recruiting practices are important. For example, use of contractors and postdoc fellows (IEEE Fellows) at NRL are good ways to get strong scientists working on projects that interest them and the Navy. Programs such as these successfully prepare the scientist to apply for vacancies when the time is right. The Navy might look at its oceanography and undersea warfare technology organizations to determine if a recruiting and enticement program is in place.

Several impediments related to recruiting were discussed. The NAVOCEANO example will be cited here.

1. Non-competitive salaries.
2. Location.
3. Advancement of a scientific career.

An Operational Center's mission is not to perform research and development. Their employees' jobs do not include writing papers and going to scientific conferences. As such, employees who chose to advance their science careers will look elsewhere for employment.

4. Ship duty and travel.

For some this is an enticement and for others a drawback.

5. The length of time it takes to get a clearance.

New hires, particularly young people, can't wait that long for a clearance and are forced to take another job elsewhere.

Of course there is still the concept that federal employee jobs are very stable and that makes them attractive. People want the stability of the federal employee but it is often hard to get into federal government.

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Recommendations:

Recommendations related to the key questions in this session are as follows.

- 1) What's required to retain people in the ocean sciences field?

Recommendations:

1a. Assuring them a good quality of life, challenging work, adequate pay/benefits, stable funds.

1b. Location, culture, climate, good facilities.

1c. Career potential and upward mobility opportunities.

- 2) How do we establish strong continuous relationships between the Navy and universities (partner institutions)?

Recommendations:

2a. Exchange programs including internships/summer jobs, and joint research funding.

2c. Establish education partnering agreements.

2d. Co-location of facilities.

2e. Graduate students who work on Navy relevant thesis and dissertation topics through joint collaborations between the universities and Navy Labs/Warfare centers. Navy employees can be a member of masters or PhD committees.

2f. Capitalize on ONR's Young Investigator Program, but don't restrict it to only tenure track investigators.

- 3) What type of programs can be developed to retain personnel?

Recommendations:

3a. Offer advanced education programs to employees.

Right now Labs/Warfare Centers have programs that allow their scientists to attend classes to receive and advanced degrees. However, these costs must be covered directly by the Labs/Warfare Centers. This can be a significant restriction for working capital funded organizations and therefore these opportunities are often limited. There must be dedicated funds for these advanced degrees that reduce this limitation.

3b. Scientist (or educator) to sea/shore programs.

For these programs to be successful, the operational commands need to buy into the concept and be willing to spend the time and money to do this.

Session VI: Expanding advanced education for Navy personnel in oceanographic sciences

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Overview: To determine how to expand advanced education for Navy personnel, the working group discussed the following questions: How can we expand graduate school enrollment of Naval Officers? What other advanced education opportunities should be made available?

Observations:

Generally, if careers or organizations are not routinely exposed to different viewpoints, or new ideas, than one's effectiveness can wither. Depending on one solution, a solution accepted within a cloistered organization, can lead to a loss of advantage. Naval Officers, specialists and unrestricted line Officers, follow rather traditional/predictable career paths and they are crowded with mandatory wickets. The Navy needs to expand from traditional training opportunities, break from the normal thinking and be open to new ideas.

The Naval Postgraduate School (NPS) model is designed to get a Naval Officer to the Master's level in difficult subjects like Acoustics or Oceanography/Meteorology while considering the student Officer may have been away from formal education for 5-10 years. It recognizes the career tempo of a "deploying Service." Yet, per comments made at the TFO opening meeting, there is a "... stigma within Navy about pursuing graduate education." This is likely not the case for restricted line Officers, but it can be for the unrestricted line (e.g., submariners who are already intensely trained in nuclear power). A question then arises: Can NPS offer, or coordinate, other more appealing opportunities? NPS might partner, for credit, with other schools in Norfolk (e.g., ODU), Mississippi (e.g., USM), San Diego (e.g., UCSD)—just a few examples. Such arrangements may allow any Officer to start taking some courses earlier in his/her career and in convenient places. Further, such partnerships may expose the student Officers to teachers who may have different experiences, alternative viewpoints, and different "solution sets;" from those taught to most Officers attending NPS exclusively.

There is a cost issue to be considered for the education of Navy personnel. For example, NPS is less expensive than WHOI-MIT and different academic institutions have different costs. This cost issue should be further investigated but ultimately more funds would be required to send more Officers to other graduate schools.

One downside of spreading Officers across multiple academic institutions all over the country is the issue for universities of having enough students in the class. If you only have a few Officers and only a few other students then it may be hard to justify teaching that course. The MIT-WHOI Joint Program encounters this problem even with non-Navy students in acoustics, where the minimum number of students in a class is three, because there are not enough students for a class. One solution that was carried out by NAVOCEANO for students going to the University of New Orleans was an agreement with the university to pay extra for a required class if there were vacant seats. Another possible solution to this problem would be to encourage universities to coordinate better among themselves and share the responsibility to offer a suite of ocean acoustic courses using distant learning technologies.

Math skills are a key challenge for Naval Officers returning for a master's or doctoral degree after spending some years in the fleet. Are the math courses currently offered to Naval Officers providing the

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right math skills for graduate training in acoustics, autonomy, and other topics of high interest to Naval Officers? It would be useful to identify those math skills that are needed for specific graduate topics and then make it clear which on-line courses are most useful for specific topics. The review could engage both Naval personnel, as well as university faculty involved in teaching the graduate topics of interest.

Another problem for educating Navy personnel is the amount of time that they can dedicate to education. For example, sailors are mobile. They are only in one place for two-to-three years. Therefore, their education and training opportunities are limited. Credits may or may not be transportable. NAVOCEANO employees are on sea duty and deployed 50-60% of time, so they may only be able to get one college level course per year.

Certificate programs like USM unmanned systems certificate may be a solution. Specific programs with specific training for sailors may serve as a foundation for a degree once they get out of the service. However, there has to be an incentive to want a certificate. The enlisted Sailor might rather have college credit towards a bachelor's instead of a certificate. New certification programs must be carefully developed so they are attached to a certain set of Navy-approved credentials and competencies. New certificate programs related to interpreting models or assessing risk and decision making should be developed. The requirements and required competencies should be defined so new programs can be developed.

The Navy needs to learn what programs academic institutions are creating for their own needs and then see if those programs can be reshaped or repackaged for Navy needs.

Getting a doctoral degree requires several years out of the Navy. That can impact an Officer's career. Once they have obtained a degree, they're excited to use the science they just learned but don't always get to operationalize the science they just worked on for several years. We need to increase their incentive for getting an advanced degree by making sure that they are given the opportunity to use their degree once they have earned it.

All of these advanced education ideas come down to desire and resources. Making these advanced education opportunities related to promotion, both for civilians and Navy personnel, should increase the desire to go in this direction.

Recommendations:

1. Expand graduate school enrollment of Naval Officers to national oceanographic institutions.
2. Establish USW/METOC civilian institution programs at additional oceanographic academic institutions.
3. Ensure that credits earned by students are transportable to other colleges and universities.
4. Short sabbaticals should be created to gain new views for the Officer in his/her field.

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Sabbaticals might include joining a research team at university for a year or being sent to a company as liaison to Navy on a new acoustic sensor's development. The idea is to break from the normal thinking and get a new idea.

5. Develop certification programs through which enlisted personnel can receive training and education in a particular subject area relevant to Naval Oceanography requirements.
6. Develop short courses at universities or ocean research institutions for Officers or enlisted Sailors (week to weeks) on key topics such as AUVs.
7. Continued support for/focus on graduate education for Officers and additional training (college or certificate) for enlisted (who should be encouraged to get a further education and encourage a METOC degree).
8. Investigate the possibility of degrees obtain through university partnering (NPS and other universities as an example)
9. Incentivize the METOC community in a similar way to that which is done for the submarine community.
10. Increase the size of the Professional Development Centers and have them provide additional new, necessary training.
11. Develop fellowship programs at warfare centers where METOC systems are embedded (NAVAIR, NAVSEA, NUWC, etc.)
12. Encourage Navy Officers to have input into course syllabus where possible and perhaps even teach a course.
13. Investigate setting up and making available Massive Open Online Courses to meet degree requirements.
14. The Navy should work with academic institutions to create more opportunities for enlisted personnel to convert their knowledge into a degree to keep the separating or retiring Sailors in the marine industry.

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Appendix A: Agenda

8 August 2017

0830 Arrive Naval Observatory

0900 Call to Order Workshop/Administrative Announcements

0910 Introductions

0930 Briefing on Task Force Ocean (Objectives/Expectations): CAPT A. J. Reiss

1015 Break

1030 Session I: Future Capacity and Capability for U.S. Naval Oceanography Community

Brief: Naval Oceanography Enterprise: Ms. Megan Natter (CNMOC)

- In order to support CNO readiness and fleet size in 2020-2030, what should the Naval Oceanography operational manpower requirements be, both Civilian and Military, with respect to what they are today? What aspects of manpower might have to increase/decrease?
- What are key obstacles, with respect to scientific workforce, to increasing Naval Oceanography production capacity in line with Fleet readiness requirements (e.g. at the Naval Oceanographic Office)?

1230 Break for Lunch

1330 Session II: Assess workforce levels for the Naval Research and Development Enterprise with a focus on Ocean Science and Acoustics.

- What key issues define/limit the workforce size?
- How does the workforce size today compare to that of past decades?
- Can/will/should this change? If so, how?

1500 Break

1515 Session III: Improve U.S. Ocean Science community's awareness of Naval applications of Ocean Science and Technology

- How is the Ocean Science Community currently made aware of Naval Applications (or are they)?
- Does the Ocean Science Community understand the process of getting from basic research to operational application? If not, how can we make this connection?

1700 Adjourn

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9 August 2017

0830 Arrive Naval Observatory

0900 Call to Order Workshop/Administrative Announcements

0915 Brief: Ocean Science Board Activities Dr. Susan Roberts (Chair, Ocean Studies Board)

0945 Break

1000 Session IV: Strengthen U.S. National Scientific base in Key Scientific Fields (e.g. Physical Oceanography, Acoustics, Geophysics)

- Can we define some of the next grand challenges, navy relevant science problems for acoustics and oceanography?
- How can we improve diversity within U.S. national scientific base in these fields?
- How do we solve the problem of the lack of scientists who can obtain a clearance?

1200 Break for Lunch

1300 Session V: Improve recruiting and retention efforts within the Navy's technical workforce and Navy-partner institutions.

- How do we establish strong, continuous relationships between the Navy and universities (partner-institutions)?
- What would it take to expand technical certification programs available to Federal ocean science workforce. (e.g., UxS certification at USM)?
- Explore the possibility of establishing not only Scientist/Educator-to-Sea programs but also programs like a scientist – to –shore based centers program exposing critical workforce to naval applications of ocean science?

1400 Session VI: Expand advanced education for Navy personnel in oceanographic science.

- How can we expand graduate school enrollment of Naval Officers to national oceanographic institutions? Can we establish USW/METOC CIVINS programs at WHOI, UW, SIO, UW, URI, UNH, OSU, UT, PSU, & UH?
- How can we expand Naval Officer participation in professional fellowships and apprenticeships in marine sciences such as the NPS/SSC Pacific Fellowship Program?
- How can we develop fellowship programs at warfare centers where METOC systems are embedded (NAVAIR, NAVSEA, NUWC, etc.)?

1530 Break

1545 Summarize Workshop Recommendations/Actions; Concluding Remarks

1700 Adjourn

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Appendix B: Participants

Preller, Ruth	Naval Research Laboratory
Todoroff, Douglas	Naval Research Laboratory
Anderson, Rebecca*	Pennsylvania State University
Baggeroer, Arthur	Massachusetts Institute of Technology
Baker, Frank	Office of the Oceanographer of the Navy (OPNAV N2N6E)
Levy, Beth	Office of the Oceanographer of the Navy (OPNAV N2N6E)
Biech, Elaine	Ebb Associates
Chandler, Emily	Office of the Oceanographer of the Navy (OPNAV N2N6E)
Commander, Kerry	Naval Surface Warfare Center
Gaffney, Paul*	Monmouth University
Glenn, Scott	Rutgers University
Graham, Monty	University of Southern Mississippi
Headrick, Robert	Office of Naval Research
Hildebrand, John*	Scripps Institution of Oceanography
Holman, Robert	Oregon State University In person
Hotaling, Liesl	Marine Technology Society
Jankowski, William	Naval Undersea Warfare Center
Jobst, William*	
Jones, Benjamin	Office of the Oceanographer of the Navy (OPNAV N2N6E)
Jones, Mary	Naval Information Forces
Klingenberger, Scott	Naval Oceanographic Office
Kuperman, William	Scripps Institution of Oceanography
McGuckin, Sean*	Naval Undersea Warfare Center
McNamara, George	Naval Undersea Warfare Center
Miles, Travis	Rutgers University
Natter, Megan	Naval Meteorology and Oceanography Command
Paduan, Jeffrey	Naval Postgraduate School
Pride, Carol	Savannah State Univ.
Ramberg, Steven	Pennsylvania State University
Reiss, AJ	Office of the Oceanographer of the Navy (OPNAV N2N6E)
Ryan, Melissa	The Global Foundation for Ocean Exploration
Sharpe, Tennyson	Office of the Oceanographer of the Navy (OPNAV N2N6E)
Yarincik, Kristin	Consortium for Ocean Leadership
Yoder, James*	Woods Hole Oceanographic Institution

*Indicated attendance via TELCON