Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Navy											Date: March 2019	
Appropriation/Budget Activity 1319: *Research, Development, Test & Evaluation, Navy I* BA 2: *Applied Research*					R-1 Program Element (Number/Name) PE 0602435N *I Ocean Wrfghtg Env Applied Res*							
COST ($ in Millions)	**Prior Years**	**FY 2018**	**FY 2019**	**FY 2020 Base**	**FY 2020 OCO**	**FY 2020 Total**	**FY 2021**	**FY 2022**	**FY 2023**	**FY 2024**	**Cost To Complete**	**Total Cost**
Total Program Element	0.000	72.530	89.998	63.894	-	63.894	64.143	70.125	76.155	77.187	Continuing	Continuing
0000: *Ocean Wrfghtg Env Applied Res*	0.000	41.145	42.998	63.894	-	63.894	64.143	70.125	76.155	77.187	Continuing	Continuing
9999: *Congressional Adds*	0.000	31.385	47.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	78.385

A. Mission Description and Budget Item Justification

The activities described in this program element (PE) address future Navy and Marine Corps capabilities needed to maintain maritime superiority and ensure national security. They are based on input from Naval Research Enterprise stakeholders (including the Naval enterprises, the combatant commands, OPNAV and Headquarters Marine Corps) and are designed to exploit breakthroughs in science and technology in order to deliver maximum warfighting benefit to our sailors and marines. These efforts are aligned with shared priorities throughout the whole of RDT&E in order to quickly advance new capabilities from discovery to deployment across the warfighting domains.

This PE provides the unique, fundamental programmatic instrument by which basic research on the natural environment is transformed into technological developments that provide new or enhanced warfare capabilities for the Battlespace Environment (BSE). The objectives of this program are met through measuring, analyzing, modeling and simulating, and applying environmental factors affecting naval material and operations in the BSE. This program provides for BSE technological developments that contribute to meeting top joint warfare capabilities established by the Joint Chiefs of Staff, with primary emphasis on Joint Littoral Warfare and Joint Strike Warfare.

This PE fully supports the Director of Defense Research and Engineering's Science and Technology Strategy and is coordinated with other DoD Components through the Defense Science and Technology Reliance process. Work in this program is related to and fully coordinated with efforts in accordance with the on-going Reliance joint planning process. There is close coordination with the US Air Force and US Army under the Reliance program in the BSE categories of Lower Atmosphere, Ocean Environments, Space & Upper Atmosphere, and Terrestrial Environments. Within the Naval Transformation Roadmap, the investment will contribute toward achieving each of the "key transformational capabilities" required by Sea Strike, Sea Shield, and Sea Basing. Moreover, environmental information, environmental models, and environmental tactical decision aids that emerge from this investment will form one of the essential components of FORCEnet (which is the architecture for a highly adaptive, human-centric, comprehensive maritime system that operates from seabed to space). The Navy program includes efforts that focus on, or have attributes that enhance, the affordability of warfighting systems.

Due to the number of efforts in this PE, the programs described herein are representative of the work included in this PE.

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B. Program Change Summary ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Previous President's Budget	42.411	42.998	43.104	-	43.104
Current President's Budget	72.530	89.998	63.894	-	63.894
Total Adjustments	30.119	47.000	20.790	-	20.790
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	47.000			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-0.684	0.000			
• SBIR/STTR Transfer	-1.697	0.000			
• Program Adjustments	0.000	0.000	20.790	-	20.790
• Rate/Misc Adjustments	0.000	0.000	0.000	-	0.000
• Congressional Add Adjustments	32.500	-	-	-	-

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2018	FY 2019
Project: 9999: *Congressional Adds*		
Congressional Add: *Program Increase*	7.243	0.000
Congressional Add: *AGOR Mid-life Refit*	19.314	0.000
Congressional Add: *Naval Special Warfare Maritime Science and Technology*	4.828	0.000
Congressional Add: *Naval Special Warfare*	0.000	10.000
Congressional Add: *Task Force Ocean*	0.000	10.000
Congressional Add: *Acoustics Research*	0.000	2.000
Congressional Add: *Multi-Modal Detection Research*	0.000	10.000
Congressional Add: *Persistent Maritime Surveillance*	0.000	15.000
Congressional Add Subtotals for Project: 9999	31.385	47.000
Congressional Add Totals for all Projects	31.385	47.000

Change Summary Explanation

The funding change in FY 2020 is due to the need to increase investment in the Ocean Warfighting Environment Applied Research project and the associated support for fleet operations for the current and/or emerging systems of research vessels of the U.S. Academic Research Fleet. Additional funds cover planned

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costs for operations, maintenance, repair and upgrades that enable applied research at sea and provides modeling and analysis for environmental compliance for ONR and Naval Research Laboratory (NRL) field work and active acoustic experiments.

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COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
0000: *Ocean Wrfghtg Env Applied Res*	0.000	41.145	42.998	63.894	-	63.894	64.143	70.125	76.155	77.187	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project provides technologies that form the natural environment technical base on which all systems development and advanced technology depend. Furthermore, this technical base provides developments that may be utilized in the Future Naval Capabilities programs: Organic Mine Countermeasures (MCM) and Autonomous Operations. This project contains the National Oceanographic Partnership Program (NOPP) (Title II, subtitle E, of Public Law 104-201) and efforts aimed at understanding and predicting the impacts of underwater sound on marine mammals.

Major efforts of this project are devoted to: gaining real-time knowledge of the Battlespace Environment (BSE), determining the natural environment needs of regional warfare, providing the on-scene commander with the capability to exploit the environment to tactical advantage and, developing atmospheric research related to detection of sea-skimming missiles and strike warfare. This project provides natural environment applied research for all fleet operations and for current or emerging systems, and continuing support to research vessels of the U.S. Academic Research Fleet for operations, maintenance, repair and upgrades that enable applied research at sea and provides modeling and analysis for environmental compliance for ONR/NRL field work and active acoustic experiments. Major developments are routinely transitioned to the Fleet Numerical Meteorology and Oceanography Center and to the Naval Oceanographic Office where they are used to provide timely information about the natural environment for all fleet operations.

Joint Littoral Warfare efforts address issues in undersea, surface, and air battlespace. Efforts include ocean and atmospheric analysis and prediction for real-time description of the operational environment, shallow water acoustics, multiple-influence sensors for undersea surveillance and weapon systems, and influences of the natural environment on MCM and Anti-Submarine Warfare (ASW) systems. Joint Strike Warfare efforts address issues in air battlespace dominance. Efforts include influences of the natural environment on air operations, electromagnetic (EM)/electro-optic (EO) systems used in intelligence, surveillance, reconnaissance, targeting, bomb damage assessment, and detection of missile weapon systems. They also include improvements in tactical information management about the BSE.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Title: Coastal Geosciences/Optics	7.775	8.019	11.552	0.000	11.552
Description: The goal of the Coastal Geosciences/Optics activity is to understand and predict the nearshore and coastal battlespace environment and its evolution. Studies address coupled phenomena affecting the hydrodynamical, geological, geophysical, and optical properties of the littorals through development of theory, predictive models and field measurement campaigns. Research results support safe and efficacious Naval Mine, Undersea, and Special Warfare operations.					
FY 2019 Plans:					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Research investments in this activity support the development and testing of models, sensors, algorithm development and testing to enable prediction of coastal battlespace environments anywhere on the globe. Efforts include ocean color remote sensing to characterize bathymetry, shallow-water bottom types, and the distribution of ocean water optical properties in the littorals and the demonstration of a compact hyperspectral imager to retrieve coastal environmental products from small UAVS. Additional efforts develop shipboard, in-situ, airborne, and spaceborne sensors and appropriate inversion and though-the-sensor techniques to create operationally and tactically useful environmental descriptions of the littorals and sea bottom. Battlespace Environments: Continue to conceptualize and perform laboratory, field, and numerical modeling studies to understand and exploit various geoscience and optical environmental phenomena in areas that are scientifically challenging, require innovation, and are of interest to the Navy/Marine Corps. Encompasses the design, performance, analysis and underlying theory of field and laboratory experiments designed to understand geological/geophysical, biological, and optical phenomena in the oceans and littoral zones, and to validate that understanding. Continue applied research to develop new or enhance existing shipboard, in-situ, airborne, and spaceborne sensors and appropriate inversion and though-the-sensor techniques to obtain, store, utilize, merge and/or exploit data and create operationally and tactically useful environmental information of the littorals and bottom. Continue specification and development of sensors, signal processing, inversion, and other analysis tools when needed. Undersea Warfare: Conceptualize and perform laboratory and field studies to understand and exploit energy storage and retrieval from the benthic interface and the potential to balance small scale and large scale intermittent power generation with power demand for persistent operation of marine sensors presently powered by batteries. ***FY 2020 Base Plans:*** Applied research investments in this activity support the development and testing of littoral models, sensors, platforms (air, surface, undersea or space) and remote sensing algorithm development to enable prediction of coastal battlespace environments anywhere on the globe. Efforts include development of new sensors and ocean remote sensing to quantify littoral geophysical variables, e.g., bathymetry, shallow-water bottom types, waves, currents, temperature, salinity, vector winds, optical properties. Battlespace Environments: Conceptualize and perform laboratory, field, and numerical modeling studies to understand and exploit various geoscience and optical environmental phenomena in areas that are scientifically					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
challenging, require innovation, and are of interest to the Navy/Marine Corps. Encompasses the design, performance, analysis and underlying theory of field and laboratory experiments designed to understand geological/geophysical, biological, and optical phenomena (including bioluminescence), in the oceans and littoral zones, and to validate that understanding. To develop models that can predict bottom boundary physical, geological, geochemical, geo-acoustic and geotechnical properties in shallow-water operating areas requires: a) an improved understanding of processes that generate and modify the shape, structure and physical properties of the seafloor and sub-seafloor, and its topography/morphology. Includes efforts to develop new or enhance existing shipboard, in-situ, airborne, and space-borne sensors and appropriate inversion and though-the-sensor techniques to obtain, store, utilize, merge and/or exploit data and create operationally and tactically useful environmental information of the littorals and bottom. This includes specification and development of sensors, signal processing, inversion, and other analysis tools when needed. Surveillance of coastal land areas and waters is important to support Navy operations. The Navy/Marine Corps needs include an improved use rapid, airborne characterization of littoral environments including time-varying coastal topography, littoral bathymetry, sea-level height, land and seafloor sedimentary structures as well as quantification of the influence of turbulence generated at the seafloor boundary layer on vertical mixing and stratification in shallow water outside the surf zone. Undersea Warfare: Conceptualize and perform laboratory and field studies to understand and exploit energy storage and retrieval from the benthic interface and the potential to balance small scale and large scale intermittent power generation with power demand for persistent operation of marine sensors presently powered by batteries. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The funding increases from FY 2019 to FY 2020 is due to the need to provide increasing support for all fleet operations for current and/or emerging systems of research vessels of the U.S. Academic Research Fleet for operations, maintenance, repair and upgrades that enable applied research at sea and provides modeling and analysis for environmental compliance for ONR/NRL field work and active acoustic experiments.					
Title: Marine Mammals and Biology	3.351	3.630	3.482	0.000	3.482

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Description: The Marine Mammals and Biology activity focus is to better understand and characterize the effects of underwater sounds produced by Navy sources (especially sonar) on marine mammals. Efforts include research on integrated ecosystems, effects of sound exposure on marine mammals, and improving the monitoring and detection of marine mammals. The research in this program supports Navy environmental compliance information needs and facilitates acquiring LOAs from NOAA that enable all Navy training and testing operations, and the development of appropriate state-of-the-art mitigation measure. ***FY 2019 Plans:*** Integrated Ecosystem Research: Continue research to understand the patterns and causes of variability in the distribution and abundance of marine mammals over space and time. Continue multidisciplinary approach using tagging, visual surveys, and passive acoustics to collect baseline measures of marine mammal behaviors and distributions relative to environmental features and marine mammal prey fields. Effects of Sound: Continue research on behavioral, physiological (hearing and stress response), and potentially population-level consequences of sound exposure on marine life. Continue research to characterize the causal chain of events leading from sound exposure to "biologically significant" behavioral reactions that might increase risks of population-level effects and/or the potential for stranding. Continue research to develop an understanding of the natural variation of stress markers, better understand and characterize the relationships among hormones or other biomarkers in different matrices and characterize the relationship between the physiological stress response in marine mammals and acoustic exposure. Monitoring and Detection: Continue research to develop and test new and existing technology to detect and classify marine mammals in the marine environment and during periods of low light. Continue the development and testing of new autonomous hardware platforms using passive acoustics and/or IR to detect and classify marine mammals. ***FY 2020 Base Plans:*** Extramural Marine Mammals and Biology - Areas of research include monitoring and detection, integrated ecosystem, and effects of sound on marine mammals. Integrated Ecosystem Research: Further research using animal tagging and passive acoustic monitoring to study behaviors,					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
movement and distribution of marine mammals relative to key environmental properties (biotic and abiotic). Effects of Sound: Conduct research on behavioral effects to potentially population-level consequences of sound exposure on marine life. Initiate research to characterize the gas management and kinetics (stores and use) in marine mammals. Conduct research into the mechanisms that enable marine mammals to dive to deep depths for long durations while mitigating, if not avoiding, health threats. Conduct research to advance our understanding of sound reception mechanisms in mysticetes (large whales) will require a thorough exploration of the anatomy surrounding the ear and the whole head combined with modeling sound propagation through various tissues of whale heads and/or bodies. Conduct research to develop an understanding of the natural variation of stress markers, better understand and characterize acute and chronic effects of the stress response on individuals and populations of marine mammals. Conduct research on potential effects of Navy sources on marine mammal behavior, life functions (e.g. feeding, breeding, migrating), vital rates (e.g. adult survival, reproduction), and population level effects. Understanding the effects of naval activities on species or stocks of marine mammals, including effects on annual rates of recruitment and survival. Monitoring and Detection: Conduct research and development of technology for detection, classification, and localization of marine mammals. Models & Databases: Conduct research to provide tools to support environmental compliance efforts and decision making related to how marine mammals are affected by anthropogenic sounds. Initiate research using increase in funds to characterize and quantify the cumulative effects of multiple stressors on marine mammal populations. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** There is no significant change from FY 2019 to FY 2020.					
Title: Marine Meteorology	9.265	9.567	9.908	0.000	9.908
Description: The Marine Meteorology activity develops observing technologies, models, Numerical Weather Prediction (NWP) systems and Tactical Decision Aids (TDA) that describe the atmospheric environment and its impacts on naval sensors and operations. This activity focuses on uniquely marine aspects of atmospheric					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
science such as air-sea interaction, coupled ocean-atmosphere modeling, Electric Magnetic (EM) and Electric Optical (EO) propagation, coastal meteorology, Tropical Cyclone (TC) prediction, and the use of remote sensing to obtain quantitative observations of atmospheric properties. Aspects of the atmospheric environment of particular interest include near-surface phenomena that affect refractivity, marine boundary layer dynamics that affect clouds, rain, visibility and fog, and processes that control TC structure, track, and intensity. Objectives of this activity are improved NWP systems and TDAs that provide NOWCAST and forecast skill at global, regional, and tactical scales for operational support, sensor and system development, and performance prediction. ***FY 2019 Plans:*** Perform field measurements; theoretical analyses; development of data fusion, data assimilation and modeling technologies; increasing knowledge content of data from remote sensing and through-the-sensor systems; exploring dynamical and physical processes, coupled atmosphere/ocean/wave/ice/land processes, atmospheric predictability, and methodologies for probabilistic forecasting and characterization of uncertainty. Studies encompass the design, performance, analysis and underlying theory of field and laboratory experiments and telescoping, global-to-tactical scale numerical simulations specifically designed to understand atmospheric environmental processes and phenomena. These studies include efforts to develop appropriate inversion and other techniques to obtain atmospheric environmental data from airborne and spaceborne sensors. Research is coordinated with operational customers to enable rapid transition of research into operations. Initiate the development of a version of the Navy's regional NWP prediction system (COAMPS) that incorporates new physics and is optimized to provide much more accurate forecasts in the Arctic, particularly for poorly predicted phenomena like polar lows, and couples with ocean and ice forecast models. Battlespace Environments: Perform field measurements; theoretical analyses; development of data fusion, data assimilation and modeling technologies; increasing knowledge content of data from remote sensing and through-the-sensor systems; exploring dynamical and physical processes, coupled atmosphere/ocean/wave/ice/land processes, atmospheric predictability, and methodologies for probabilistic forecasting and characterization of uncertainty. Encompasses the design, performance, analysis and underlying theory of field and laboratory experiments and telescoping, global-to-tactical scale numerical simulations specifically designed to understand atmospheric environmental processes and phenomena. Includes efforts to develop appropriate inversion and other techniques to obtain atmospheric environmental data from airborne and spaceborne sensors. Includes empirical and numerical model development techniques and associated efforts designed to improve atmospheric prediction, diagnose problems and increase the efficiency and accuracy of those models and model systems in a variety of computational environments. Includes efforts to fuse, merge and exploit atmospheric data and					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
create operationally useful information. The research is coordinated with operational customers to enable rapid transition of research into operations. ***FY 2020 Base Plans:*** Perform field measurements; theoretical analyses; development of data assimilation and modeling technologies; increasing knowledge content of data from remote sensing and through-the-sensor systems; improve the representation of dynamical and physical processes, coupled atmosphere/ocean/wave/ice/land processes, atmospheric predictability, and methodologies for probabilistic forecasting and characterization of uncertainty. These studies include efforts to develop appropriate techniques to obtain atmospheric environmental data from airborne and spaceborne sensors. Additional effort is focused on parameters that affect Electric Optical (EO) and Electric Magnetic (EM) propagation in the marine environment. Develop and improve/optimize the Navy's regional Numerical Weather Prediction (NWP) prediction system (COAMPS) by increasing resolution and incorporating new physics and numerical methods to provide much more accurate forecasts, particularly for poorly predicted phenomena like Arctic storms, and coupling with ocean and ice forecast models. Develop and improve tropical cyclone forecast models through improved physics, coupling to the ocean and upper atmosphere, assimilation of new observations, data assimilation methods and novel ensemble methods that quantify forecast uncertainty. Conduct research on a next-generation global NWP model that incorporates efficient numerical methods, variable-resolution grids, improved representation of physics, and that can operate efficiently on future computation systems. The goal is to potentially replace the rectangular nested-grid systems currently in use, and combine global and regional modeling into a unified and more efficient system. Encompasses the design, performance, analysis and underlying theory of field and laboratory experiments and telescoping, global-to-tactical scale numerical simulations specifically designed to understand atmospheric environmental processes and phenomena. Includes efforts to develop appropriate inversion and other techniques to obtain atmospheric environmental data from airborne and space-borne sensors. Includes empirical and numerical model development techniques and associated efforts designed to improve atmospheric prediction, diagnose problems and increase the efficiency and accuracy of those models and model systems in a variety of computational environments. Includes efforts to fuse, merge and exploit atmospheric data and					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
create operationally useful information. The research is coordinated with operational customers to enable rapid transition of research into operations. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** There is no significant change from FY 2019 to FY 2020.					
Title: National Oceanographic Partnership Program (NOPP) ***Description:*** This activity focuses on US Navy investments in the National Oceanographic Partnership Program (NOPP). NOPP, established by the US Congress (Public Law 104-201) in Fiscal Year 1997, is a unique collaboration among 15 federal agencies involved in conducting, funding, or utilizing results of ocean research. NOPP's value to the Navy derives from the capacity of the partnership to enable and ensure multi-agency efforts where such collaboration enhances efficiency or effectiveness, and/or reduces costs. NOPP topics address scientific problems that cross-agency missions, fall in gaps between agencies and/or are too large for any one agency to fund itself. ***FY 2019 Plans:*** Further development of an integrated coastal ocean observation system and development of sensors, communications and data acquisition, storage and processing tools required to affect it, modernization of ocean research and observation infrastructure, and marine mammal-related research. Continue applied research activities to include conducting studies to develop an integrated coastal ocean observation system and associated sensors, communications, data acquisition, storage and processing tools. Continue efforts to develop small space-based sensors for littoral oceanographic and atmospheric dynamics research; tools for improved production and application of high resolution sea surface temperature data; and miniaturized, next generation sensors for ocean measurements. ***FY 2020 Base Plans:*** The focus remains on topics that cross agency missions and/or are too large for one agency to address alone; this includes ocean/coastal dynamical process studies, observation and modeling systems, development of sensors, communications and data acquisition, storage and processing tools required to affect it, modernization of ocean research and observation infrastructure, and marine mammal-related research. Conduct of studies focused on model verification, constraint of boundary conditions and fluxes of mass, heat and momentum across them (air-sea, deep ocean-seabed, land-sea), and responses to storm and/or persistent forcing are anticipated.	8.470	8.781	8.742	0.000	8.742

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Expand the development and utilization of small space-based sensors for oceanographic and atmospheric dynamics research; and miniaturized, low-power, next generation sensors for ocean measurements. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** There is no significant change from FY 2019 to FY 2020.					
Title: Ocean Acoustics ***Description:*** The Ocean Acoustics activity is dedicated to the determination of the impact of the natural ocean environment on acoustic wave phenomena in support of naval undersea warfare and underwater force protection operations. This activity studies underwater acoustic propagation, scattering from ocean boundaries, and ambient noise issues that impact the development and employment of acoustic systems. The littoral zone has been the ocean environment of greatest interest. Aspects of this environment, that greatly impact underwater acoustic systems, are the shallow water, the consequent closeness and physical significance of the ocean bottom, and the complexities inherent to rapid changes of the ocean structure. The objectives of this program are met through measuring, analyzing, modeling and simulating, and exploiting ocean acoustic factors to gain advantage over potential adversaries using undersea acoustic systems. Results of this activity support acoustic sensor and system development, performance prediction, and tactical decision aids. This Activity will also focuses on efforts addressing research needs identified by Task Force Ocean that will enable tactical maneuver for the future submarine force. The efforts funded by this Program Element (PE) fall generally into two topic areas: Analysis and understanding of the impact of environmental conditions on Large Vertical Aperture (LVA) Array sonar data, and the development of reduced order ocean-acoustic models to enable environmental awareness and prediction on forward platforms. ***FY 2019 Plans:*** Continue applied research to provide the Warfighter with improved Anti-Submarine Warfare (ASW) performance assessment models and tactical decision aids to plan ASW operations, evaluate effectiveness of ASW systems, and enable environmental adaptive system control. Continue to provide ASW sensor and system performance models, realistic simulations, and measures of effectiveness that incorporate and exploit critical environmental knowledge requires coupling ocean dynamics and acoustics, ambient noise characterization in the littorals, acoustic and optical scattering and propagation characterization, through-the-sensor measurement techniques	2.026	2.074	19.052	0.000	19.052

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
for in situ environmental parameters, measurement and prediction of uncertainty, and development of tactical decision tools. Continue efforts of applied research to enhance passive sonar performance capability in the Arctic environment by developing a better passive sonar performance prediction model and new acoustic ice-characterization methods.					
FY 2020 Base Plans: Conduct research efforts to enable environmental awareness and tactical exploitation of the environment by forward naval platforms. Activities will include the development of technologies and algorithms to incorporate in situ environmental sensing into an on-scene environmental characterization capability, inversion of sensor data to infer the local environment, and the development of capabilities to exploit the ocean environment for tactical advantage. Research efforts are informed by the outcome of the Tactical Oceanography Symposia series conducted by the Office of Naval Research, which involve academic researchers, industry partners, and the operational Navy. Conduct applied research to provide the Warfighter with improved Anti-Submarine Warfare (ASW) performance assessment models and tactical decision aids to plan ASW operations, evaluate effectiveness of ASW systems, and enable environmental adaptive system control. The capability to provide ASW sensor and system performance models, realistic simulations, and measures of effectiveness that incorporate and exploit critical environmental knowledge requires coupling ocean dynamics and acoustics, ambient noise characterization in the littorals, acoustic and optical scattering and propagation characterization, through-the-sensor measurement techniques for in situ environmental parameters,measurement and prediction of uncertainty, and development of tactical decision tools. Efforts include continuation of applied research to enhance passive sonar performance capability in the Arctic environment by developing a better passive sonar performance prediction model and new acoustic ice-characterization methods.					
FY 2020 OCO Plans: N/A					
FY 2019 to FY 2020 Increase/Decrease Statement:					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
The increase from FY 2019 to FY 2020 is due to the initiation of the Task Force Ocean project to gain a better understanding on the oceans, especially in the Artic, with respect to global prediction based on the outcome of the Chief Naval Operations Task Force Ocean working groups and recommended courses of action.					
Title: Physical Oceanography	10.258	10.927	11.158	0.000	11.158
Description: The goal of the Physical Oceanography activity is to develop knowledge of the physics of the ocean within the battlespace environment to enable tactical naval use and exploitation of the battlespace. This is achieved through the development of predictive models of the water mass structure, waves, currents, and air-sea interactions and developing measurement/observation technology. Other applications utilize knowledge of the interaction of the water column hydrodynamics and the acoustics to predict the undersea transmission characteristics and sources of uncertainty in these statistics. Utilizing knowledge of the ocean surface physics, the physical oceanography program seeks to exploit the combination of remotely sensed data, in-situ data, and adaptively sampled data to optimize predictions of ocean currents and water column structure. These predictions, custom databases, adaptive sampling schemes and data programs serve Anti-Submarine Warfare, Naval Special Warfare, and Mine and Expeditionary Warfare. This Program requires field research that involves participation in Navy Environmental planning efforts including environmental planning documents (Environmental Impact Statements). The use of active acoustic transmissions requires modeling of the acoustic effects of sound on marine life. ***FY 2019 Plans:*** Conduct applied oceanographic research including field campaigns to study ocean processes and dynamics, ocean model development, and data assimilation from the open ocean to the nearshore environments. Data assimilation development extends use of coupled modeling approaches to include air-ice-wave-ocean-land models. Studies develop new or enhance existing shipboard, in-situ, airborne, and spaceborne sensors and appropriate inversion and "through the sensor" techniques to obtain physical oceanographic environmental data, and to fuse and exploit oceanographic data to create operationally useful information. Efforts continue to develop and test the Remote Ocean Sampling System for air-sea surface flux sampling as well as developing advanced autonomy for operations of gliders in extreme environments. Additional efforts develop ocean drifters with stable salinity sensors and high resolution turbulence sensors. Continue the effort to develop a capability to estimate global ocean forecast uncertainty from ensembles which will enable risk assessment with skill out to 30 days, providing the real-time assessment of environmental uncertainty anywhere on demand and risk					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602435N / *Ocean Wrfghtg Env Applied Res*	**Project (Number/Name)** 0000 / *Ocean Wrfghtg Env Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
analysis products that can be used as inputs to existing decision support tools such as risk quantification and mission planning. Continue the effort to develop a new capability for accurate and rapid characterization of the local ocean battlespace utilizing the ability of gliders to work in coordinated teams and 4-dimensional variation assimilation to maximize impact of the glider data in a high-resolution local forecast model for more accurate ocean predictions Battlespace Environments: A program including field research on ocean processes and dynamics, ocean model development, and data assimilation from the open ocean to the nearshore and riverine environments is directed towards model system development and analysis. Model and data assimilation development is extending to the field of coupled models including air-ice-wave-ocean-land models. Encompasses the design, analysis and underlying theory of field and laboratory experiments designed to understand ocean environmental processes and phenomena. It includes model development to improve ocean environmental predictive capabilities, through improved physical characterization, diagnosis, efficiency and accuracy of these models in a variety of computational environments. Also includes efforts to develop new or enhance existing shipboard, in-situ, airborne, and spaceborne sensors and appropriate inversion and "through the sensor" techniques to obtain physical oceanographic environmental data. Includes effort to fuse and exploit oceanographic data to create operationally useful information. The research is coordinated with operational customers to enable its rapid transition into operational systems.					
FY 2020 Base Plans: Conduct applied oceanographic research including field campaigns to study ocean processes and dynamics, ocean model development, and data assimilation from the open ocean to the nearshore environments. Data assimilation development extends use of coupled modeling approaches to include air-ice-wave-ocean-land models. Studies develop new or enhance existing shipboard, in-situ, airborne, and space borne sensors and appropriate inversion and "through the sensor" techniques to obtain physical oceanographic environmental data, and to fuse and exploit oceanographic data to create operationally useful information. The testing of the Remote Ocean Sampling System for air-sea surface flux sampling will be completed following the deployments in the North Atlantic. Efforts to develop advanced autonomy for the operations of gliders in extreme environments is also completed. Testing of gliders with turbulence sensors, Unmanned Underwater Vehicles (UUVs) with turbulence sensors will continue. Additional efforts develop ocean drifters with stable salinity sensors and high resolution turbulence sensors will continue.					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Continue the effort to develop a capability to estimate global ocean forecast uncertainty from ensembles which will enable risk assessment with skill out to 30 days, providing the real-time assessment of environmental uncertainty anywhere on demand and risk analysis products that can be used as inputs to existing decision support tools such as risk quantification and mission planning. Continue the effort to develop a new capability for accurate and rapid characterization of the local ocean battlespace utilizing the ability of gliders to work in coordinated teams and 4-dimensional variation assimilation to maximize impact of the glider data in a high-resolution local forecast model for more accurate ocean predictions. Testing of ocean instrumentation that features energy harvesting will be initiated. The TOPSIDE software of the data server module will be tested with ocean data sets that are publically available and cloud computing and serving will be evaluated and tested. Battlespace Environments: A program including field research on ocean processes and dynamics, ocean model development, and data assimilation from the open ocean to the nearshore and riverine environments is directed towards model system development and analysis. Model and data assimilation development is extending to the field of coupled models including air-ice-wave-ocean-land models. Encompasses the design, analysis and underlying theory of field and laboratory experiments designed to understand ocean environmental processes and phenomena. It includes model development to improve ocean environmental predictive capabilities, through improved physical characterization, diagnosis, efficiency and accuracy of these models in a variety of computational environments. Also includes efforts to develop new or enhance existing shipboard, in-situ, airborne, and spaceborne sensors and appropriate inversion and "through the sensor" techniques to obtain physical oceanographic environmental data. Includes effort to fuse and exploit oceanographic data to create operationally useful information. The research is coordinated with operational customers to enable its rapid transition into operational systems. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** There is no significant change from FY 2019 to FY 2020.					
Accomplishments/Planned Programs Subtotals	41.145	42.998	63.894	0.000	63.894

C. Other Program Funding Summary ($ in Millions)

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
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C. Other Program Funding Summary ($ in Millions)

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

All Science and Technology model improvements undergo a rigorous validation verification and evaluation against quantifiable metrics before being accepted for transition into operations. In Marine Meteorology, for example, typical improvements over the past decade have amounted to a gain in skill of one forecast-day (i.e., the 4-day forecast is now as skillful as the 3-day forecast of a decade ago), and tropical cyclone forecast track error has been reduced by 50%. It is expected that future increases in skill will continue at or above this pace.

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy			Date: March 2019
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602435N / *Ocean Wrfghtg Env Applied Res*	Project (Number/Name) 9999 / *Congressional Adds*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
9999: *Congressional Adds*	0.000	31.385	47.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	78.385

A. Mission Description and Budget Item Justification

Congressional Interest Items not included in other Projects.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019
Congressional Add: Program Increase ***FY 2018 Accomplishments:*** Additional funds will enhance new Task Force Ocean programs to enable tactical exploitation of the ocean environment. ***FY 2019 Plans:*** N/A	7.243	0.000
Congressional Add: AGOR Mid-life Refit ***FY 2018 Accomplishments:*** Additional funds provided in the FY18 Appropriation for the AGOR 23 Class Mid-Life Refit supports the replacement or upgrade of the Bow Thruster propulsion systems on the AGOR 23 Class vessels. AGOR 23 R/V Thomas G Thompson completed its major, mid-life refit overhaul, shakedown and testing, and re-entered the U.S. Academic Research Fleet in support of Navy oceanographic research objectives. ***FY 2019 Plans:*** N/A	19.314	0.000
Congressional Add: Naval Special Warfare Maritime Science and Technology ***FY 2018 Accomplishments:*** Funds supported applied oceanographic research to exploit ocean currents, water surface and seafloor roughness, and ocean optoacoustical properties, among other phenomena, to enhance underwater vehicle and diver operations. ***FY 2019 Plans:*** N/A	4.828	0.000
Congressional Add: Naval Special Warfare	0.000	10.000

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019
FY 2018 Accomplishments: N/A ***FY 2019 Plans:*** Funds supported applied oceanographic research to exploit ocean currents, water surface and seafloor roughness, and ocean optoacoustical properties, among other phenomena, to enhance underwater vehicle and diver operations.		
Congressional Add: Task Force Ocean ***FY 2018 Accomplishments:*** N/A ***FY 2019 Plans:*** Exploration of analytic techniques linking physical oceanographic variability with acoustic propagation, including field efforts to collect relevant data sets. The development and use of artificial intelligence and machine learning techniques for large ocean and acoustic data sets. Through-the-sensor environmental characterization, including assimilation into nested local environmental prediction models. Exploration and development of advanced signal processing techniques that incorporate local ocean structure, including ambient noise characterization	0.000	10.000
Congressional Add: Acoustics Research ***FY 2018 Accomplishments:*** N/A ***FY 2019 Plans:*** Research in applied acoustics, advanced sensor capabilities and better undersea environment data to directly characterizing the physical environment and provide information to monitor ecosystem health, impacts, and change. This investments will support the potential for improved performance of US Navy soar systems for surveillance and reconnaissance.	0.000	2.000
Congressional Add: Multi-Modal Detection Research ***FY 2018 Accomplishments:*** N/A ***FY 2019 Plans:*** Research in non-acoustic detection, tracking, localization, and identification of underwater threats.	0.000	10.000
Congressional Add: Persistent Maritime Surveillance ***FY 2018 Accomplishments:*** N/A ***FY 2019 Plans:*** Conduct supplemental study and research supporting advances in technologies to enable Persistent Maritime Surveillance capabilities.	0.000	15.000
Congressional Adds Subtotals	31.385	47.000

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
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C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Congressional Interest Items not included in other Projects.