PMEL
Pacific Marine Environmental Laboratory

Transitions or Transfers to Operations/Applications, 2014 – 2020

What was transitioned or transferred?	When?	To what organization or group?	Benefit of transition or transfer
PIRATA Array Eastern Atlantic T-Flex Implementation and Operations	2016-Ongoing	IRD (*Institut de Recherche pour le Développement*); Météo-France; PMEL Global Tropical Moored Buoy Array program	T-Flex moorings improve data resolution and flexibility with commercially available instrumentation. Four of six eastern Atlantic PIRATA moorings maintained with France have been transitioned to T-Flex moorings. PMEL hosted French technicians for T-Flex mooring training in FY16 and FY 19. France now conducts mooring operations without PMEL technicians on the cruises.
PIRATA Array Western Atlantic T-Flex Implementation and Operations	2017-Ongoing	INPE (*Instituto Nacional de Pesquisas Espaciais*); DHN (*Diretoria de Hidrografia e Navegação*); PMEL Global Tropical Moored Buoy Array program	T-Flex moorings improve data resolution and flexibility with commercially available instrumentation. Three of eight western Atlantic PIRATA moorings maintained in partnership with Brazil have been transitioned to T-Flex moorings. PMEL hosted Brazilian technicians for T-Flex mooring technical training in FY 2017. Brazil Navy DHN officers also participated on the 2019 NOAA PIRATA cruise to train on mooring operational procedures. Brazil is now conducting T-Flex mooring operations without PMEL technicians on the cruises.
PIRATA Array Central Atlantic T-Flex Implementation	2015-2017	PMEL Global Tropical Moored Buoy Array program	T-Flex moorings improve data resolution and flexibility with commercially available instrumentation. All four central Atlantic PIRATA moorings maintained by NOAA have been transitioned to T-Flex.
RAMA Capacity Building with India	2014-Ongoing	India's Ministry of Earth Sciences (MoES), including: National Institute of Ocean Technology (NIOT) and India's National Center for Ocean Information Services (INCOIS)	Capacity building activities improve global data standards and cooperation and MoES provides ship time to maintain and sustain the RAMA array. In FY20 PMEL hosted Indian technicians for T-Flex mooring technical training and Indian data scientist for moored buoy data processing and quality control (QC) training in FY 2019. PMEL continues ongoing work with NIOT staff on RAMA cruises and instrumentation best practices.
RAMA Capacity Building with Indonesia	2014-Ongoing	Indonesia's Meteorological, Climate, and Geophysical Agency (BMKG)	Capacity building activities improve global data standards and cooperation and BMKG provides ship time to maintain and sustain the RAMA array. PMEL hosted Indonesian scientists for data processing and quality control (QC) training in FY 2020. PMEL continues work with BMKG staff on RAMA cruises and instrumentation best practices.

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RAMA T-Flex Implementation	2015-Ongoing	MoES/NIOT; BMKG; PMEL Global Tropical Moored Buoy Array group	T-Flex moorings improve data resolution and flexibility with commercially available instrumentation. 9 RAMA moorings maintained with India and Indonesia have transitioned to T-Flex moorings.
RAMA-OMNI Moorings	2018-Ongoing	India's Ministry of Earth Sciences (MoES), including: National Institute of Ocean Technology (NIOT) and India's National Center for Ocean Information Services (INCOIS)	In 2018 India's MoES announced a new open data policy for OMNI moored buoys in international waters, which paved the way for a new partnership between NOAA and MoES to more closely coordinate RAMA and OMNI field work and data dissemination. This RAMA-OMNI transition improves access to high-quality moored time series data from the Indian Ocean and improves coordination of ship time to maintain RAMA.
TELOS data acquisition system technology	2019-Ongoing	From PMEL Engineering to PMEL Global Tropical Moored Buoy Array program, PMEL Ocean Climate Stations program	TELOS data acquisition system technology offers full resolution transmission of data in real-time, a modernized replacement solution for obsolete components, and greater flexibility with a variety of sensors measuring additional essential variables. The first TELOS prototype moorings were deployed in the Pacific Ocean in 2019.
RAMA decadal review and reconfiguration	2018-2019	PMEL Global Tropical Moored Buoy Array program; Climate and Ocean Variability, Predictability, and Change (CLIVAR); Indian Ocean Observing System (IndOOS)	A decadal review of RAMA was conducted by the IndOOS review panel. Review resulted in a reconfiguration and redesigned array optimizing core measurements and eliminating sites with greater risk of vandalism and limited ship access. The reconfigured RAMA array (RAMA-2.0) was approved and transitioned in 2019.
PIRATA decadal review	2019	PMEL Global Tropical Moored Buoy Array program; Climate and Ocean Variability, Predictability, and Change (CLIVAR)	A decadal review of PIRATA was conducted by the CLIVAR review panel. The outcome of this review was enhancing core measurements and minor refinement.
Hydrophone and mooring technology for ocean noise network	2014-2019	All six NMFS regional science centers, NOS Marine Sanctuaries, National Park Service	First comprehensive measurement of baseline ocean sound levels across all US coasts

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Hydrophone mooring technology for Antarctic research	2014-2019	Korean Polar Research Institute, University of Grenada-Spain, National Science Foundation,	Enables long-term acoustic recording of ice-shelf stability and marine mammal distributions near the coast of Antarctica, locations where little previous data exists
Full-ocean depth hydrophone	2015	OAR Ocean Exploration and Research Program (OER)	First long term record of ambient sound at Challenger Deep, the deepest spot in the global oceans
High frequency, passive acoustic recording module (WISPR-2 400 kHz)	2019-Ongoing	PMEL Engineering program and ITAE, Embedded Ocean Systems, LLC/Kongsberg	This type of passive acoustic recording module does not exist commercially. Will be an option for Kongsberg Sea gliders.
Winch Mooring	2020-Ongoing	US Navy Office of Naval Research (ONR), Living Marine Resources Program (LMR), and PMEL ITAE	Enables deep-ocean sound and CTD recording in areas of heavy surface sea-ice conditions. Onboard sensor can detect low sea-ice, and then deploy positively buoyant satellite antennae to transmit data in near real time.
Slocum gliders with passive acoustic modules	2014-2019	OAR Administrator Award Program, National Science Foundation (NSF), OAR Ocean Acidification Program	Enabled widespread spatial sampling of acoustic environment. First recording of actively erupting deep-ocean volcano near America Samoa. Also baseline sound survey of natural and anthropogenic sound sources along the Washington and Oregon coasts.
Spar buoy and drifting hydrophone	2014-2019	DOE Pac-wave energy program, US Navy, NMFS-Ocean Acoustics, OSU Sea Grant, OAR Omics Program	Measurement of ambient sound levels at Wave-energy buoy test facility off Newport, OR to assess noise impacts of various wave energy buoy designs. Also measure sound levels to detect blue whales for biopsy and eDNA sampling as part of MICs project. Also measured man-made sound levels to assess stress impacts on gray whales near Newport.
Acoustic sea-ice sensor and recording module for Prawlers	2019-Ongoing	PMEL Engineering program and Innovative Technology for Arctic Exploration program (ITAE)	Acoustic sensor on mooring will detect ice-free conditions in Arctic to ensure safe surfacing of the FCOM/Phoenix Prawler.
PMEL Carbon Group transitioned deployment and recovery activities of Chuuk Ocean Acidification Buoy.	2017-2019	Korea Institute of Ocean Science and Technology (KIOST)	This capacity building effort supported by PMEL and the NOAA-KIOST Joint Program Agreement allowed KIOST to expand ocean acidification observing beyond Chuuk, to buoys deployed in Korean coastal waters and coral reefs in Samoa and Palau. PMEL continues to manage Chuuk buoy data and prepare sensors for deployment, though capacity-building activities to transition these tasks will continue the next 5 years.

PMEL Carbon Group led a workshop: "Technical Meeting on the Management, Analysis and Quality Control of Ocean Acidification Observation Data" hosted by the Ocean Acidification International Coordination Centre (IAEA)	2019	Carbon scientists from fifteen countries underrepresented in the global ocean observing community.	Workshop trained scientists from fifteen countries in theory and demonstration of best practices for ocean acidification data collection and analyses, increasing capacity for ocean acidification research in countries underrepresented in the global ocean observing community.
PMEL Carbon Group helped transition a research product to an easy to access quality-controlled CO2 and pH time series from 40 locations around the world now available via NCEI.	2019	NOAA National Centers for Environmental Information (NCEI)	This data product makes the time series more accessible to students, researchers from other disciplines, and marine resource managers who may not have a seawater CO2 chemistry background or the resources necessary to process and interpret the more detailed originally archived data.
Aerosol Unmanned Aircraft Systems (UAS) payload demonstration in an operational environment in Svalbard	2015	Scientific research community (aerosol measurements)	Demonstrated indicated to aerosol measurement experts in and outside of NOAA that UAS are a viable option for making vertical profiles of aerosol properties in remote regions.
Miniature Autonomous Plume Recorder (MAPR)	2006-Ongoing	Oceanographers from many institutions worldwide, NOAA Ocean Exploration and Research Program (OER), Ocean Exploration Trust, and others.	Used worldwide to identify and discover hydrothermal plumes that enhance our knowledge of seafloor tectonic systems.
Targeted metabarcode assay for zebra and quagga mussels	2019	International Research Community and Managers for Invasive Species	Accurate & cost effective early detection of invasive mussel species from water and plankton samples
Targeted metabarcode assay for invasive silver and bighead carps	2019	International Research Community and Managers for Invasive Species	Accurate & cost effective early detection of invasive carp species from water and plankton samples
Metabarcode assays for invasive fishes and invertebrates from bait and pond stores	2019-2020	International Research Community and Managers for Invasive Species	Accurate & cost effective detection of invasive fish and invertebrate species in retail
Metabarcode assays for invasive mollusks from Environmental DNA	2017-2019	International Research Community and Managers for Invasive Species	Accurate & cost effective detection of invasive mollusk species from environmental DNA

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Improved Tsunami Ocean Observations	2012-2017	Paroscientific Inc.	Frequency counting board for near-field tsunamis (co-development)
Development of technology to increase the observations of carbon and ocean acidification in the oceans and atmosphere	2012-2015	Battelle Memorial Institute	MapCO2 for measuring carbon flux for assessing ocean carbon uptake.
DART (Deep-ocean Assessment and Reporting of Tsunamis) - 4G	2017-Ongoing	SAIC	Deep-water mooring for improved detection of earthquake-generated tsunamis closer to the wave source, especially in the near-field.
Prawler commercialization	2017-2019	McLane Labs	The Prawler device, which is attached to the mooring line, uses wave-powered energy to crawl up the line, taking temperature and salinity, oxygen, and chlorophyll measurements along the way. The Prawler (Profiler + Crawler) enables CTD profiling using wave energy from a surface mooring, and is a step towards next-generation moored buoys.
Prawler transfer	2019	PMEL EcoFOCI program	The Prawler device, which is attached to the mooring line, uses wave-powered energy to crawl up the line, taking temperature and salinity, oxygen, and chlorophyll measurements along the way. The Prawler (Profiler + Crawler) enables CTD profiling using wave energy from a surface mooring, and is a step towards next-generation moored buoys for NOAA's only biophysical mooring observing system in the US Arctic.
Prawler transfer	2019	NASA Salinity Processes Upper-ocean Regional Study (SPURS) Surface Water and Ocean Topography (SWOT) Mission	The Prawler device, which is attached to the mooring line, uses wave-powered energy to crawl up the line, taking temperature and salinity measurements along the way. The Prawler (Profiler + Crawler) enables dynamic height measurements for satellite comparisons of sea surface height (SSH).
Prawler MOU transfer	2019	Commonwealth Scientific and Industrial Research Organization (CSIRO) - Australia	The Prawler device, which is attached to the mooring line, uses wave-powered energy to crawl up the line, taking temperature and salinity measurements along the way. The Prawler (Profiler + Crawler) enables CTD profiling using wave energy from a surface mooring, and is a step towards next-generation moored buoys

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Oculus Underwater Glider and sensors	2017-Ongoing	Kongsberg (intellectual property transferred from University of Washington; technical capacity transferred from PMEL)	Novel buoyancy engine and unique profiling capabilities, increase speed and shallow water capability. Includes CTD, Fluorometer and Turbidity (FLNTU) sensors, and dissolved oxygen (DO) sensors
ASVCO2 (™) Systems on Wave Gliders (MOU)	Ongoing	Jupiter Research Foundation	Unmanned wave gliders are a simple, cost-effective platform for collecting ocean data that does not rely on expensive ships or buoys. Wave glider technology increases observations of carbon and ocean acidification in the oceans and atmosphere.
Moorings technical capacity (from PMEL Engineering)	2017	University of Alaska/Fairbanks (UAF)	Improved coastal mooring deployments/recovery
PMEL Engineering and Tsunami programs: DART-4G Deep-ocean Assessment and Reporting of Tsunamis): Chile Evaluation, Support, and Training	2015-Ongoing	Servicio Hidrográfico y Oceanográfico de la Armada de Chile/Hydrographic and Oceanographic Service of the Chilean Navy (SHOA), National Weather Service/National Buoy Center	Chile (SHOA) was provided technical capacity to maintain DART 4G mooring technology (deep-water moorings for improved detection of earthquake-generated tsunamis) closer to the wave source in the near-field off Chilean coast.
PMEL Engineering program transferred mounting transceivers to taut-line moorings	2015	Dalhousie University (Canada)	Mounting transceivers to taut-line moorings allow for tracking of movements and survival of marine animals carrying acoustic tags and how both factors are influenced by oceanographic conditions.
Saildrone US Arctic Field Program: Basic sensor suite (PMEL Engineering program, Innovative Technology for Arctic Exploration program (ITAE)	2019	NOAA Marine Fisheries Service (NMFS), NMFS Alaska Fisheries Science Center, other NMFS Fisheries Science Centers	Data collected using the Saildrone platform has provided unique and groundbreaking insights that are changing our understanding of marine ecosystems and inform conservation management decisions. The data collected can improve the accuracy of large ecosystem models in predicting changes in the ecosystem, protecting marine mammals, and aiding in fisheries management.
Saildrone US Arctic Field Program: WBAT & WBT-mini (Fisheries Echosounder)	2019	NOAA Marine Fisheries Service (NMFS), NMFS Alaska Fisheries Science Center, other NMFS Fisheries Science Centers	Saildrones equipped with fisheries echosounders augment ship-based fish survey efforts and may also provide higher resolution fish detection measurements, which can be used to inform fisheries management decisions.
Pop-up Float/Buoy: Basic and Applied Research of Platform for Observation of the Water-Ice Boundary (ITAE)	Ongoing	NOAA Marine Fisheries Service (NMFS), Office of Oceanic and Atmospheric Research (OAR)	Low-cost moored float with timed-release to study how ice retreat modifies physical and environmental factors in the US Arctic.

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Saildrone US Arctic Field Program and TPOS-2020 pilot study: CO2, Autonomous Surface Vehicle (ASV) CO2 (2nd generation)	2019	NOAA Office of Oceanic and Atmospheric Research (OAR), Saildrone	Measures partial pressure of CO2 in the atmosphere and surface ocean using a simple, cost-effective platform. ASV technology increases observations of ocean carbon uptake and ocean acidification.
Saildrone TPOS-2020 pilot study and US Arctic Field Program: Radiometers	Ongoing	NOAA Office of Oceanic and Atmospheric Research (OAR), National Weather Service (NWS), Saildrone	Saildrone-equipped radiometers measure direct and diffuse solar radiation that can be corrected for platform motion. Important for ocean heat studies.
Optical pCO2 sensor	2016-2017	AANdera	Prototype sensor evaluation for optical pCO2. In-situ evaluation and characterization.
DART Single Housing (PMEL Engineering program)	2019	National Weather Service/National Buoy Center	Increases reliability, reduces number of pressure housings, saves costs.
Arctic Heat Open Science Experiment autonomous ocean profiler development: Air-Launched Autonomous Micro-Observer (ALAMO) Float (MOD for under-ice observations)	2015-2019	MRV Systems LLC, Office of Oceanic and Atmospheric Research (OAR), National Weather Service (NWS)	Under ice observations to improve ice forecasts
Arctic Heat Open Science Experiment autonomous ocean profiler development: Air-Launched Autonomous Micro-Observer (ALAMO) Float (Natural Parachute)	2018-Ongoing	MRV Systems LLC	Reduce plastics in ocean
NetCDF data template designs for Saildrone-derived oceanographic and meteorological data	2017	Saildrone and NASA	The well-defined NetCDF data template allows for the transfer of self-described (full metadata record) data between different entities in a modern interoperable data format.
Open-GTS (Global Telecommunications System) to improve data access to the GTS platform	2019	World Meteorological Organization (WMO)/UNESCO Intergovernmental Oceanographic Commission (IOC) J-COMM (Joint Technical Commission for Oceanography and Marine Meteorology) Observations Coordination Group	Removes technical and bureaucratic barriers to placing scientific data on the World Meteorological Organization's (WMO) Global Telecommunications System (GTS), which allows improved application of oceanographic and other scientific data relevant to operational weather in oceanographic forecasts.

Ocean Tracer Program transferred a PMEL-developed technique for measuring Nitrous Oxide in seawater samples.	2016	University of Texas/Austin	Transfer included a custom install of software and additional chromatographic columns.
Ocean Tracer Program transferred a PMEL-developed software update to our multichannel trace gas analysis system	2018	University of Washington trace gas lab	Software update allowed for more accurate trace gas measurements and analysis.
Ocean Tracer Program headed a working group transferring N2O measurement technologies	2018	Several academic institutions	Technology transfer allowed for more accurate N2O measurements.
Ocean Tracer Program prepared and provided N2O and CH4 standard tanks	2016	12 US research institutions	Transfer allowed more accurate measurements of N2O and CH4.
In Ecosystem Status Report 2019 Eastern Bering Sea, PMEL EcoFOCI program contributed to "Eastern Bering Sea Climate – FOCI," which includes temperature data and sea ice extent at M2 & M8 (two Bering Sea long-term moorings maintained by EcoFOCI)	Annually	NOAA Fisheries, North Pacific Fishery Management Council	Ecosystem Status Reports are produced annually to compile and summarize information about status of Alaska marine ecosystems for the North Pacific Fishery Management Council, the scientific community and the public. There are separate reports for the Eastern Bering Sea (updated 2019), Aleutian Islands (updated 2018), the Gulf of Alaska (updated 2019), and Arctic (forthcoming) ecosystems. These reports include ecosystem report cards, ecosystem assessments, and ecosystem and ecosystem-based management indicators that together provide context for ecosystem-based fisheries management in Alaska.
In Ecosystem Status Report 2019 Eastern Bering Sea, PMEL EcoFOCI program contributed to "Phenology and Magnitude of Primary Production in the Eastern Bering Sea," which includes new primary production index from the Prawler.	Annually	NOAA Fisheries, North Pacific Fishery Management Council	Ecosystem Status Reports are produced annually to compile and summarize information about status of Alaska marine ecosystems for the North Pacific Fishery Management Council, the scientific community and the public. These reports include ecosystem report cards, ecosystem assessments, and ecosystem and ecosystem-based management indicators that together provide context for ecosystem-based fisheries management in Alaska.

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In Ecosystem Status Report 2019 Eastern Bering Sea, PMEL EcoFOCI program contributed to "Phytoplankton Biomass and Size Structure During Late Summer to Early Fall in the Eastern Bering Sea," which includes data from BASIS (Bering Arctic Subarctic Integrated Survey) cruises.	Annually	NOAA Fisheries, North Pacific Fishery Management Council	Ecosystem Status Reports are produced annually to compile and summarize information about status of Alaska marine ecosystems for the North Pacific Fishery Management Council, the scientific community and the public. These reports include ecosystem report cards, ecosystem assessments, and ecosystem and ecosystem-based management indicators that together provide context for ecosystem-based fisheries management in Alaska.
In Ecosystem Status Report 2019 Eastern Bering Sea, PMEL EcoFOCI program contributed to "Coccolithophores in the Bering Sea"	Annually	NOAA Fisheries, North Pacific Fishery Management Council	Ecosystem Status Reports are produced annually to compile and summarize information about status of Alaska marine ecosystems for the North Pacific Fishery Management Council, the scientific community and the public. These reports include ecosystem report cards, ecosystem assessments, and ecosystem and ecosystem-based management indicators that together provide context for ecosystem-based fisheries management in Alaska.
EcoFOCI mooring and shipboard data products	Annually	Alaska Ocean Observing System (AOOS)	Contributing to understanding of recent warming in the Bering Sea and its impact on the ecosystem
EcoFOCI mooring and shipboard data products	2017-Annually, 2019-Annually	NOAA Arctic Report Card	Contributing to understanding of sea surface temperature (SST)(since 2017), and to recent warming in the Bering Sea and its impact on the ecosystem (since 2019)
EcoFOCI mooring and shipboard data products	Annually	Distributed Biological Observatory (DBO)	Contribute to understanding of dramatic seasonal retreats and thinning of sea ice, record-setting seawater temperatures and multiple observations of biological changes in the Pacific Arctic to evaluate ecosystem response to climate forcing.

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EcoFOCI mooring and shipboard data products	2016-2017	Recruitment Processes Alliance	In 2017, North Pacific Climate Regimes and Ecosystem Productivity provided key scientific information that enabled effective management and sustainable use of Alaska marine resources. Ecosystem science in 2016 and 2017 directly influenced decision-making by the North Pacific Fishery Management Council in determining the Alaska walleye pollock total allowable catch (TAC) and contributed to the Alaska Marine Ecosystems Considerations Report, used by the Council and other stakeholders, to evaluate current ecosystem status and project near-future conditions.
EcoFOCI mooring and shipboard data products	2018-2019	Recruitment Processes Alliance	Provided key scientific information that enabled effective management and sustainable use of Alaska marine resources. Ecosystem science in 2018 and 2019 directly influenced decision-making by the North Pacific Fishery Management Council in determining the Alaska pacific cod total allowable catch (TAC) and contributed to the Alaska Marine Ecosystems Considerations Report, used by the Council and other stakeholders, to evaluate current ecosystem status and project near-future conditions. To provide the necessary data to make informed management decisions, NOAA Research and Fisheries scientists worked together to produce on-board sampling (Rapid Larval Assessment), expedited data work up, careful synthesis, and swift communication of results
PMEL Arctic Research program was lead on Arctic climate assessment: “Snow, Water, Ice and Permafrost in the Arctic (SWIPA)” produced by the Arctic Monitoring and Assessment Program (AMAP)	2017	Arctic Council	Provides reliable and up-to-date information essential for the development of science-based decision-making regarding ongoing changes in the Arctic and their global implications.
Real-Time Automatic Madden-Julian Oscillation (MJO) Precipitation Tracking Algorithm	2019	National Weather Service, National Centers for Environmental Prediction (NCEP) and Climate Prediction Center (CPC)	To quantify prediction skill of Madden-Julian Oscillation (MJO) precipitation in real time for accurate assessment of error sources in MJO global impact.

PMEL Tsunami program produced SIFT (Short-term Inundation Forecasting for Tsunamis) tsunami forecasting system, ver 3.1	2017	Servicio Hidrográfico y Oceanográfico de la Armada de Chile/Hydrographic and Oceanographic Service of the Chilean Navy (SHOA)	Transfer was part of an agreement with SHOA to deploy and maintain 2 DART 4G prototype systems off their coast in test mode. SIFT Version 3.1 will allow SHOA to perform DART buoy inversions for near-field communities along their coast from data reported by their DART II systems and DART 4G test prototypes.
PMEL Tsunami program produced SIFT (Short-term Inundation Forecasting for Tsunamis) tsunami forecasting system, ver 4.0	2018 (test mode), 2020 (operation)	National Weather Service, Pacific Tsunami Warning Center (PTWC) and National Tsunami Warning Center (NTWC)	SIFT Version 4.0 incorporates GPU parallelized computations for inundation forecast as well as a number of necessary configurations modifications to comply with NWS IT security requirements as specified in the Federal Information Systems Management Act (FISMA).
PMEL Tsunami program produced the "Community Model Interface for Tsunami" (ComMIT) version 1.8.1 as a capacity building tool in support of tsunami mitigation and education.	2015-Ongoing	Different countries in the Caribbean, Pacific and Indian Oceans including Belize, Jamaica, Fiji, and Indonesia	Arbitrary Source Calculations in ComMIT allow the user to simulate earthquakes defined by an arbitrary sea-floor deformation. Prior to the development of this feature, users were restricted to use sources expressed as linear combinations of NCTR unit source database.
PMEL Tsunami program produced the tsunami situational awareness tool (TsuCat), originally developed for South Pacific Island Countries with limited Internet access, now distributed widely.	Annually	International Center for Tsunami Research (ITIC); National Weather Service Tsunami Warning Centers (TWCs).	Most recent version (4.1) generates TWC-type test event graphical products and message for internal use of TWCs. This enormously facilitates the work of the Pacific Tsunami Warning Center (PTWC) and other national TWCs to prepare and organize tsunami warning exercises.
PMEL Arctic program delivered detailed summary of model results and analysis on CO2 emission uncertainties after 2040, snow effects, and IPCC model scenarios.	2019	NOAA Senior Advisor for Regulatory Programs, NOAA Fisheries	The endangered status of Alaskan ice seals is an ongoing issue with policy impact, and the model results and analysis provided by the PMEL Arctic program informed NOAA leadership plans and policies for ice seals.
PMEL Arctic program lead citizen science-derived historical weather and sea ice data collection	2014-Ongoing	NOAA National Centers for Environmental Information (NCEI) and National Science Foundation (NSF) databases	Provided historical weather and sea ice data to NCEI and NSF databases for valuable climate reconstruction analysis.
PMEL Arctic program delivered primary source (image) weather and ice data	2012-Ongoing (Archives), 2019-Ongoing (NCAR)	National Archives and National Centers for Atmospheric Research (NCAR)	Supports new Research Data Archive (RDA) research on machine learning based auto-transcription of document images.

PMEL Arctic program transferred technical capacity in Arctic cyclone research using NOAA light aircraft (preliminary dropsonde investigations with NRL). Also transferred weather data to global forecast centers via GTS and NRL, and operational-technical assessment to OMAO/AOC.	2019-Present	US Navy, Naval Research Laboratory (NRL), NOAA Office of Marine and Aviation Operations (OMAO) Aircraft Operations Center (AOC)	Improved ability to observe and understand Arctic cyclones and their impacts on sea ice.
PMEL Arctic program building technical capacity via providing data from autonomous floats in the Arctic (ALAMO)	2016-Present	Global forecast centers, NOAA Earth Systems Research Laboratory (ESRL)	Data are transferred to global forecast centers via GTS and on demand for research purposes (e.g. NOAA ESRL sea-ice model evaluation)
PMEL Arctic program building technical capacity in improved long-range freeze-up projections for Alaska	2017-Present	National Weather Service Arctic Sea Ice Program (ASIP), sea-ice research centers	Improved long-range sea-ice freeze-up projections for Alaska
PMEL Earth-Ocean Interactions (EOI) program transferred specialized hydrothermal fluid sampling technology to academic research partner	2017-2018	University of South Carolina	Transfer enabled academic research partner to design and build new samplers, thus increasing hydrothermal fluid sampling to expand understanding of hydrothermal ecosystem functioning.
Saildrone and PMEL Ocean Climate Stations (OCS) technology development: Acoustic Doppler Current Profiler (ADCP) and direct covariance flux measurements	2016	NOAA Office of Oceanic and Atmospheric Research (OAR), Saildrone	Measures ocean current profiles that are corrected for motion of platform. Ultrasonic 3-d wind sensor can be used to estimate wind stress directly as a covariance of the vertical and horizontal turbulent wind variations.