NASA and Exploring (Oceans)

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Science on the Living Earth or Another Planet

EXPLORATION

DISCOVERY

RESEARCH
NASA SCIENCE
Earth Science
NASA’s Earth Science Division

Research

Flight

Applied Sciences

Technology
Earth Science Instruments on ISS:
RapidScat, CATS, LIS, SAGE III (on ISS), TSIS-1, OCO-3, ECOSTRESS, GEDI, CLARREO-PF
International Space Station
Earth
Science Instruments

SAGE III (CY2016)
CATS (2015-)
HICO (2009-2014)
GEDI (2020)
ECOSTRESS (2020)
RapidSCAT (2014-)

ISERV (2012-2015)

LIS (2016)

External Logistics Carriers – ELC-1, ELC-2, ELC-3
External Stowage Platforms – ESP-3
Alpha Magnetic Spectrometer
Columbus External Payload Facility
Kibo External Payload Facility

CLARREO Pathfinders (CY2019)
Earth’s Circulatory System
Ocean Salinity and Daily Argo Coverage
SUSTAINABLE FISHERIES

Fisheries depend on a healthy, balanced ocean. Earth-observations from NASA and its partners allow scientists to monitor and predict change in the ocean that influence ocean productivity (e.g., El Niño and La Niña) as well as the overall health of our planet. From the tiniest of organisms (e.g., phytoplankton) to global ocean temperatures, NASA keeps many “eyes” on our living planet.
SeaWiFS Biosphere Data Over the North Atlantic
MARINE PROTECTED AREAS

A marine protected area is an area of sea especially dedicated to the protection and maintenance of biodiversity, and of natural and associated cultural resources, and managed through legal or other effective means. Marine parks, nature reserves and other marine protected areas can include: reefs, seagrass beds, shipwrecks, archaeological sites, tidal lagoons, mudflats, saltmarshes, mangroves, rock platforms, underwater areas on the coast and seabed in deep water. NASA satellite data can be used to understand and model ocean ecosystem health.
Monitoring Coral Reefs
Hot Spots
Pre-Aerosol, Cloud, ocean Ecosystem (PACE) Mission
The oceans are different.

Back in 1960 when people descended to the deepest part of the ocean for the very first (and last) time, they turned on the outside lights and there, in front of the viewport at a depth of over seven miles (35,802 ft (10,912 m)), was a strange looking little fish looking back at them.

This "flatfish at the very nadir of the earth" was living at a place where the water pressure was more than 8 tons per square inch, or the equivalent of one person trying to support 50 jumbo jets.

You could cut Mount Everest off at sea level and put in on the ocean floor at the bottom of the Marianas Trench, where that little fish was swimming, and there would still be over a mile of water over the top of it.
While we may think that the only mysteries left to discover await us on distant planets, there are still plenty of wondrous creatures to study and incredible places waiting to be explored right here in our own backyard....especially in the ocean.

The blue whale, *Balaenoptera musculus*, is the largest known animal ever to have lived on sea or land and can reach more than 110 feet and weigh nearly 200 tons - more than the weight of 50 adult elephants?

One recent study of a deep-sea community revealed 898 species from more than 100 families and a dozen phyla in an area about half the size of a tennis court. More than half of these were new to science.

Consider the fact that there exists a creature in the oceans that we know to be the world's largest invertebrate, that can grow to at least 60 feet in length, has eyes as large as volleyballs but which has never been seen alive in its' natural habitat. Although the Giant Squid may be the stuff of legend, it is very real indeed and is just one of the as yet unsolved mysteries of the ocean.
NASA Oceanography Program Overview

Drs. Eric Lindstrom (Physical Oceanography) & Paula Bontempi (Ocean Biology and Biogeochemistry)
NASA Headquarters, Washington, DC
Where does NASA Oceanography fit into the overall NASA mission?

- **Earth Science Division (ESD) Strategic Goal:**
  - Advance knowledge of Earth as a system to meet the challenges of environmental change and to improve life on our planet.

- **ESD Science Questions:**
  - How is the global Earth system changing?
  - What causes these changes in the Earth system?
  - How will the Earth system change in the future?
  - How can Earth system science provide societal benefit?
Physical Oceanography
Program Manager: Eric Lindstrom

- Support Physical Oceanography Missions on Orbit
  - Jason-2 (Altimetry), QuikSCAT (Winds), Aquarius (Salinity), GRACE (Gravity), RapidSCAT (Winds)

- Support Physical Oceanography Missions in Development
  - Surface Water and Ocean Topography (SWOT), Jason-3 (Altimetry),

- Support Research Teams
  - Ocean Surface Topography (OSTST), Ocean Vector Winds (OVWST), Ocean Salinity (OSST), Next Generation SST (GHRSSST), Atlantic Meridional Overturning Circulation (AMOC), Sea Level Change

- Support Climate Focus Area/Ocean Observing
  - US CLIVAR, USGCRP, GOOS, GCOS, OOPC, GODAE OceanView, NOAA COSC, IOOC, CEOS, …

- Process Studies Related to NASA Physical Oceanography Missions
Salinity Processes in the Upper ocean Regional Study (SPURS)

http://spurs.jpl.nasa.gov

What is controlling the upper ocean salinity?

This question is addressed with interagency/international collaboration of measurements from satellites, ships, drifting surface buoys & profiling floats, gliders, AUVs and theoretical & numerical model simulations.

Motivation

Launch of the Aquarius/SAC-D satellite motivates plans for field campaigns in the salinity maximum and minimum region of the North Atlantic and Eastern Tropical Pacific.
• Support Ocean Color Missions on Orbit
  – Aqua (MODIS), Suomi NPP (VIIRS)

• Support Ocean Color Missions in Development
  – PACE, GEO-CAPE, ACE, HyspIRI

• Support Research Teams
  – Ocean Color, MODIS, Suomi NPP, PACE ST

• Support Carbon Focus Area/Ocean Observing

• Process Studies Related to NASA Ocean Color Missions
  – Impacts of Climate on the Eco-Systems and Chemistry of the Arctic Pacific Environment (ICESCAPE) (2010-2011)
  – Ship Aircraft Bio-Optical Research (SABOR) campaign (summer 2014)
  – EXport Processes in the Ocean from RemoTe Sensing (EXPORTS: 2017-2022)
  – Field Campaign Scoping Study: Arctic COastal Land Ocean inteRactions Scoping study (Arctic-COLORS) (A. Mannino, NASA GSFC)
  – Field Campaign Scoping Study: Interdisciplinary Coordinated Experiment of the Southern Ocean Carbon Cycle (ICESOCC) (G. Mitchell, Scripps/UCSD)
What is the role and interaction between planktonic ecosystem characteristics and the functioning of the ocean’s biological pump?

Develop a predictive understanding of the export and fate of global ocean PP and its implications for the Earth’s Carbon Cycle in present and future climates - satellites, ships, profiling floats, gliders, and model simulations.

**Motivation**
Advances in remote sensing (e.g., PACE) and autonomous tools.
Most Phytoplankton Anywhere?

PHYTOPLANKTON ABUNDANCE GLOBALLY

Probability density function

Global average

Total water column Chlorophyll (mg m⁻²)

ICESCAPE
Before melt

The ice above the ocean is bright – it is dark under the ice
After melt

The above ice is darker – much more light is transmitted under the ice
Light and nutrients = phytoplankton bloom
Arctic Sea Ice Area

- 1979
- 2007
- 2011

million km²

Sizes of Planet Candidates
*Totals as of November, 2013*

- **Neptune-size**
  - (2–6 Earth radii)
  - 1,457

- **Super Earth-size**
  - (1.25–2 Earth radii)
  - 1,076

- **Earth-size**
  - (< 1.25 Earth radii)
  - 674

- **Jupiter-size**
  - (6–15 Earth radii)
  - 229

- **Super Giant**
  - (> 15 Earth radii)
  - 102

*Planets 2–4 Earth radii in size are sometimes called "mini-Neptunes."*
Back up
Earth Venture Suborbital – 2: Investigations

**OMG (Oceans Melting Greenland):** Investigate the role of warmer, saltier Atlantic subsurface waters in Greenland glacier melting; Josh Willis, JPL

**NAAMES (North Atlantic Aerosols and Marine Ecosystems Study):** Improve predictions of how ocean ecosystems would change with ocean warming; Michael Behrenfeld, Oregon State Univ

**ATom (Atmospheric Tomography Experiment):** Study the impact of human-produced air pollution on certain greenhouse gases; Steven Wofsy, Harvard Univ

**ACT-America (Atmospheric Carbon and Transport – America):** Quantify the sources of regional carbon dioxide, methane, and other gases, and document how weather systems transport these gases; Ken Davis, Penn State Univ

**CORAL (Coral Reef Airborne Laboratory):** Develop critical data and new models needed to analyze the status of coral reefs and predict their future; Eric Hochberg, Bermuda Institute of Ocean Science

**ORACLES (ObseRvations of Aerosols Above CLouds and Their IntEractionS):** Probe how smoke particles from massive biomass burning in Africa influences cloud cover over the Atlantic; Jens Redemann, ARC