NOAA's Recent Experience testing, evaluating and operating small Unmanned Aircraft Systems in support of marine resource surveys, oil spills and simulations.

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NOAA

Technology Workshop for Oil Spill Response in California

February 28, 2017

Outline

1. Background: UAS Oil spill testing 2008 – 2015
2. Focus over the past couple of years:
    - Reducing the time time to “respond” with UAS
    - Operating BVLOS
    - Higher resolution sensors
    - Data distribution and integration
3. Refugio oil spill integration and testing
4. Shipboard and Arctic work
5. Northwestern Hawaiian Islands
6. Antarctica
7. Future needs for maritime UAS
8. Show a couple of quick videos and one high-resolution image from Refugio

2008 aboard R/V Shearwater in Santa Barbara Channel.

Objectives included:

- Ability of the Puma system to operate at sea
- Coastal surveys for evaluation of the system's ability to determine the presence/absence of oil and survey to wildlife,
- Demonstrating the ability to function as a communications relay
- Operated BVLOS (SUA provided by Point Mugu)

Partners included: AeroVironment, USCG (USCGC HALIBUT and R&D Center), CA Fish and Wildlife/OSPR, NPS & USWFS

2011 NPREP drill aboard R/V Shearwater in Santa Barbara Channel.

Objectives included:

•Microwave Internet data relay to Incident Command Center (FMV and still images with telemetry transmitted real-time to ICC over the Internet)

•Imaging oil simulant (fluorescein dye),

•Puma as communications relay

•Quantification of geographic scope of simulated spill over time

•Coastal surveys for evaluation of the system's ability to determine the presence/absence of oil,

•Operated BVLOS (SUA provided by Point Mugu)

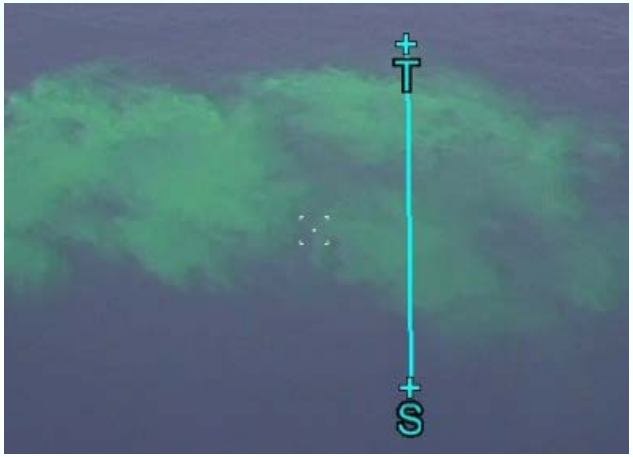
Partners included: AeroVironment, Chevron Shipping, Reality Mobile, USCG (Sector LA/LB USCGC BLACKTIP and R&D Center), NPS, USFWS, CA Fish and Wildlife/OSPR

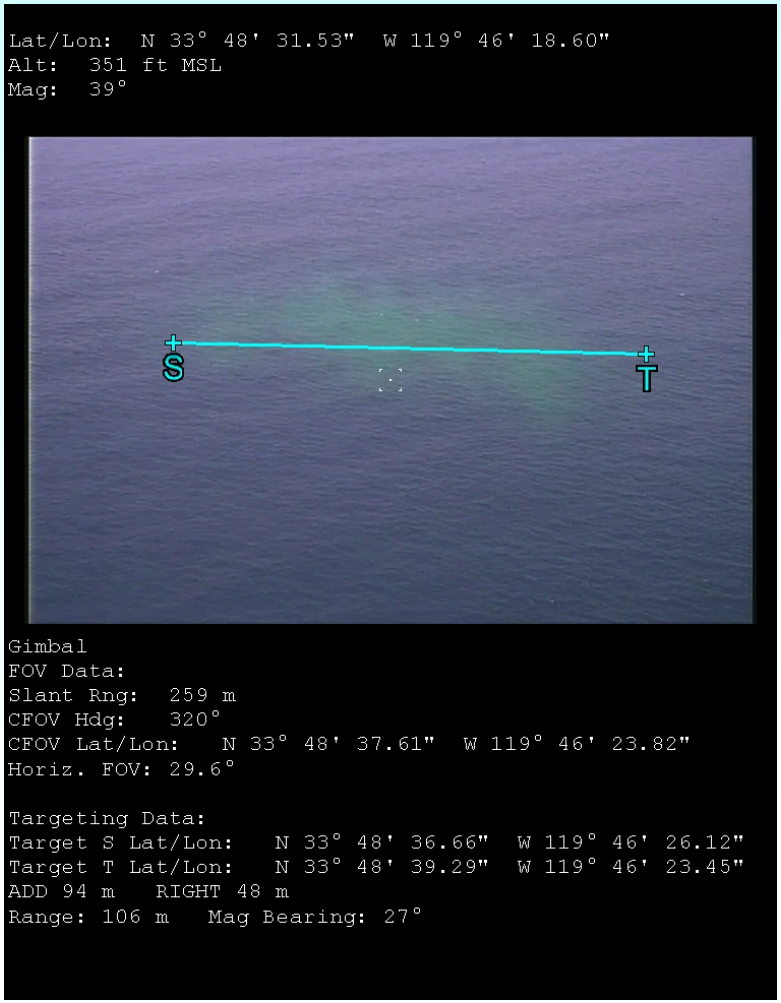
Take aways:

Someone needs to document how to effectively apply fluorescein dye!

Emergency Response & Oil Spill Simulation

Coast Guard UAS partnership study of oil spill monitoring in Santa Barbara channel





2014 aboard Shearwater and along the coast of VAFB

Objectives included:

1. Shearwater:
   - Fluorescein dye application procedure development and documentation
   - Imaging of dye and ability to use Puma UAS imagery to quantify spill
   - Testing of 2d3 image processing software
   - Real-time processing (mosaic and image optimization) and transmission of data (with telemetry) over 4G and Ku band satellite to remote locations.

2. Vandenberg Air Force Base:
   - Testing ability to use Puma UAS imagery to support SCAT surveys using stuffed animals and black plastic sheeting as oil and wildlife analog
   - Documentation of sensor resolution with calibrated targets
   - Real-time processing (mosaic and image optimization) and transmission of data (with telemetry) over Ku band satellite to remote locations.

Partners included: NOAA HAZMAT & National Marine Fisheries Service, OSPR, Chevron Shipping, 2d3 and Ku satellite support by Ground Control.

Take aways: Need higher resolution optical sensor for SCAT and Damage Assessment

Dye Release (color enhanced)

Quadrat transects at VAFB

2d3 Super Resolution Enhancement

Focus over the past two years

sUAS capacity building focus in the following areas:

- Responding to natural resource emergencies and events (Oil spill)
- Operating BVLOS
- Integration with manned aviation in controlled environments
- Polar work in support of USCG and NOAA
- Supporting development of new capabilities through partnerships and CRADAS:
  - High-resolution sensors
  - Autonomous recovery system
  - Ice sensing and deicing
- Data products and dissemination from remote locations.
- Follow on missions in promising areas
- Collaborating with other agencies to share knowledge and experience:
  - USCG
  - NASA
  - US Navy

Significant events during the past two years

Significant events in chronological order:

- May 2015: **Refugio Oil Spill** & Scheduled SB Channel Study of Natural Oil Seeps
- June 2015: **Sea turtle capture** (and tagging) support aboard the NOAA Ship Thomas B. Bigelow in the Gulf Stream in Canadian waters off of Newport, RI
- July 2015: **Arctic Shield** 2015 aboard the USCGC (Icebreaker) HEALY
- August 2015: **Northwestern Hawaiian Islands** High-resolution Mapping, Monk Seal and Marine Debris surveys aboard NOAA Ship Oscar Elton Sette with new high-resolution sensors
- November 2015: **Testing and documentation** of systems aboard the NOAA R/V Shearwater in the Santa Barbara Channel in preparation for Operation Deep Freeze 2016 (ODF-16) in support of NOAA and USCG.
  - Autonomous Net Capture System
  - Long range telemetry antennas
- Late December 2016 – February 2016: **ODF-16 2015** aboard the USCGC Polar Star (Heavy Icebreaker) in support of NOAA and USCG.

2015: UAS Rapid Response for Emergency Operations

Deploying UAS in response to disasters: *Developing the capacity for UAS to respond to disasters and provide useful/actionable data to decision makers in the formats and resolutions that they require in a timeframe that is relevant.*

At this point in time, there **was** nothing "rapid" about deploying UAS.

We are working on reducing planning and deployment time from weeks or months to hours... Working with NOAA HAZMAT to find and develop the right spill drill to exercise all of the elements necessary to truly respond to an oil spill or other disaster event.

- Contracts in place for surge capacity
- Emergency COAs, **TFRs**?
- Data accuracy and resolution
- Real-time data dissemination
- Data ingest to ERMA and other COPs

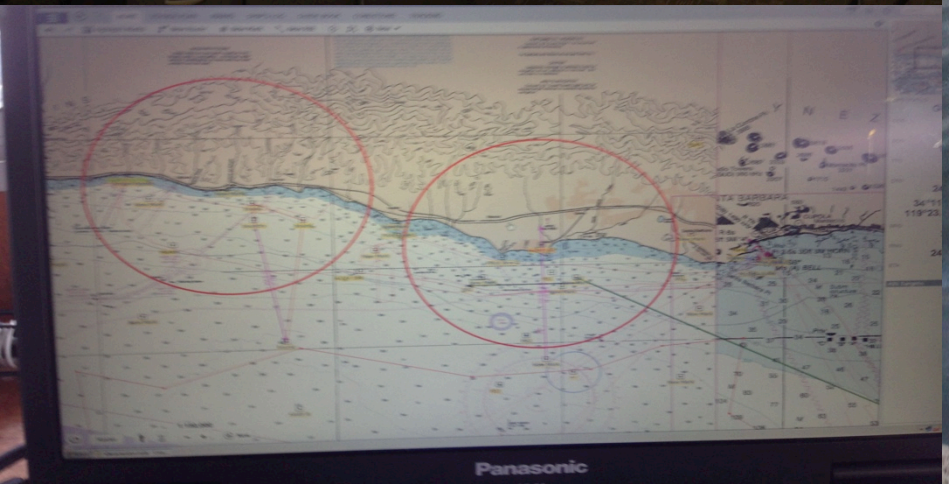
Refugio Oil Spill

Refugio Oil Spill

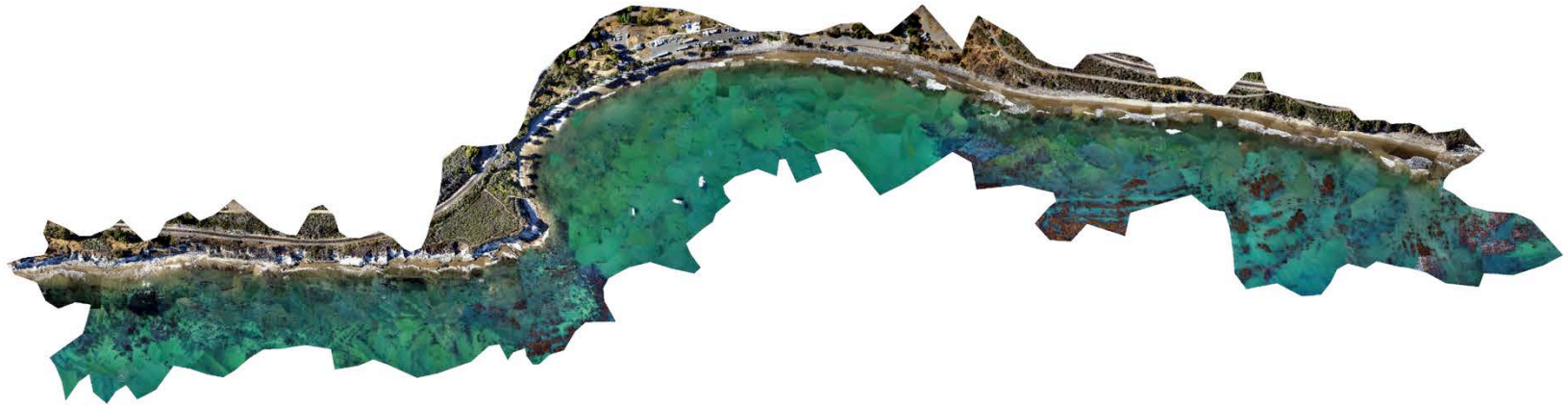
May 2015:
Refugio oil spill

- Requested by NOAA Damage Assessment Program
- Tasked by Incident command
- Supported NRDA data collection.
- Safe integration and concurrent operations with two manned helicopters
- Flew standard payload from shore and from NOAA R/V Shearwater.
- Collected high-resolution data from shore with nadir mapping camera.
- Produced stitched ortho-rectified image of Refugio bay at 2.5 cm per pixel.
- Learned quite a bit about how to integrate into Incident Command and oil spills.
- Data eventually ingested into ERMA

Refugio Oil Spill



Refugio Oil Spill



Refugio Oil Spill

Refugio Oil Spill

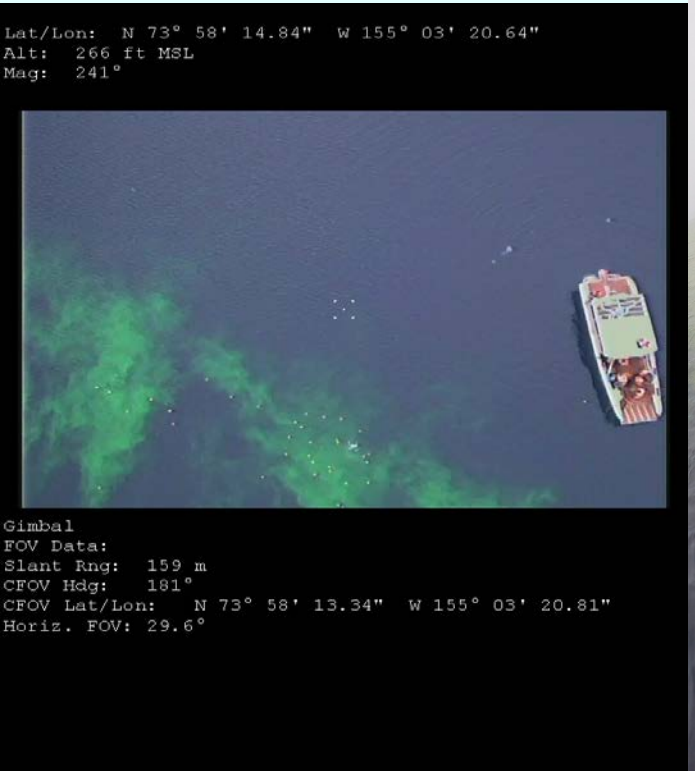
June 2015: Loggerhead and Leatherback sea turtle capture (and tagging) support

Loggerhead and Leatherback sea turtle capture (and tagging) support aboard the NOAA Ship Thomas B. Bigelow in the Gulf Stream in Canadian waters 300 nm off of Newport, RI. This was a NOAA supported event with NOAA owned Puma equipment.

Arctic Support 2013 - 2015

Arctic Shield Oil Spill Testing

2013 - 2015 Detection and monitoring of simulated oil spilled from ship

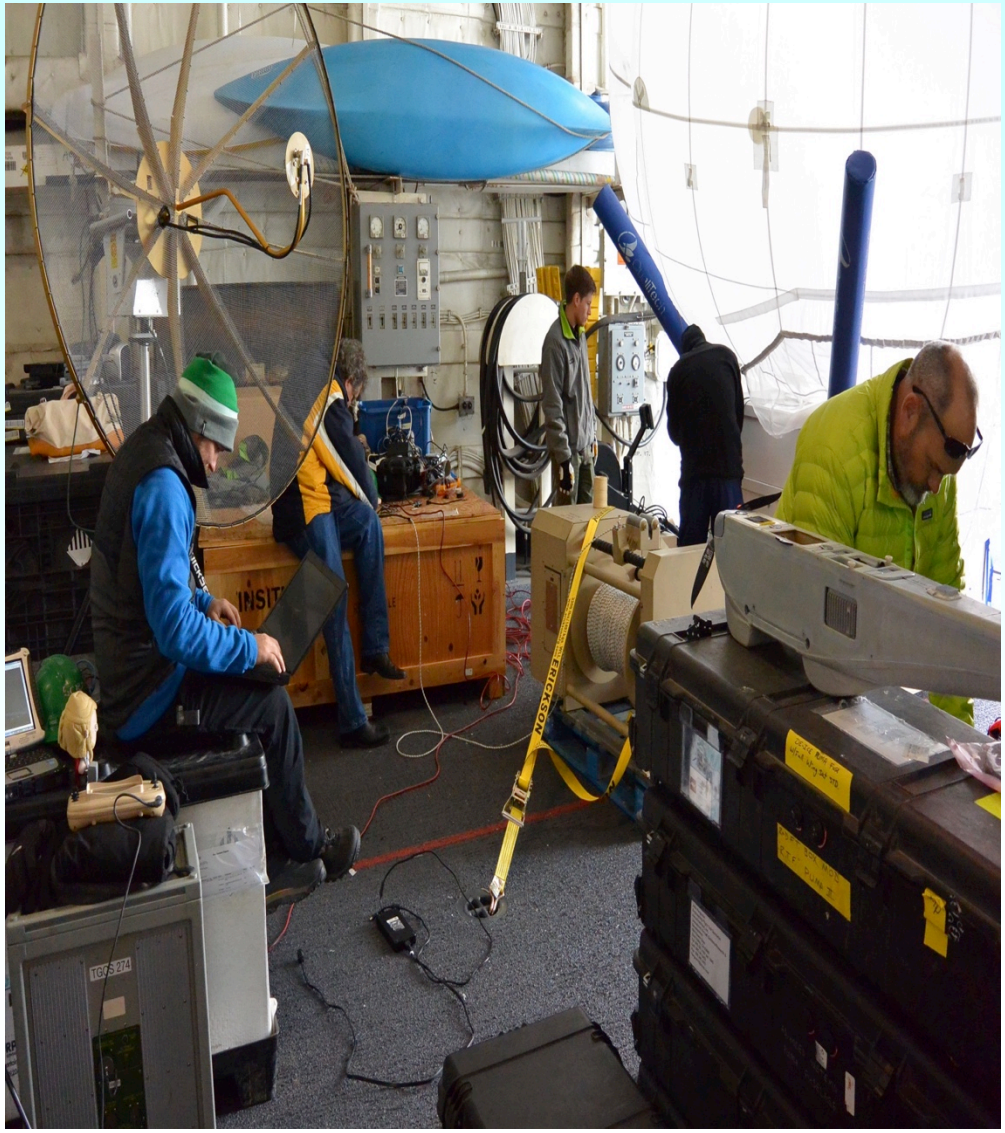


Arctic Shield July 2015 aboard the USCGC (Polar Icebreaker) HEALY.

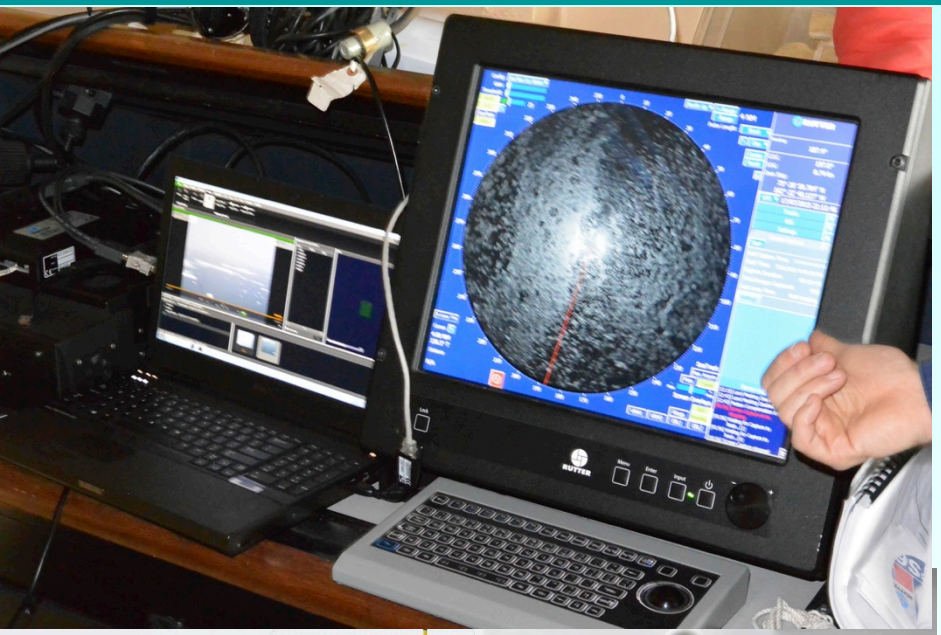
Milestones included:

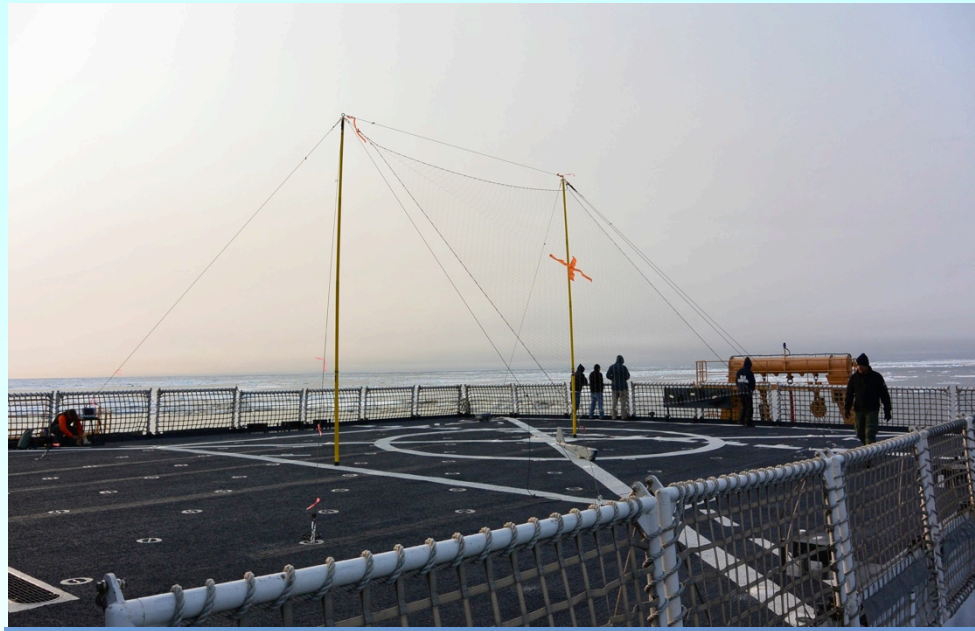
- Autonomous net recovery in rail-mounted triangular net and square net on helicopter deck
- BVLOS (5nm) operations by exercising “Due Regard”
- Real-time operations coordinated with two manned helicopters
- Testing of long range communications for C2
- Integration and testing of ice-sensing and deicing system
- Data transmission through aerostat with support from IGM Aerostatic and real-time to the Internet through satellite link with support from 2d3 and Inmarsat
- Success from this trip lead to AV and NOAA supporting ODF-16 to Antarctica.

Arctic Shield 2015

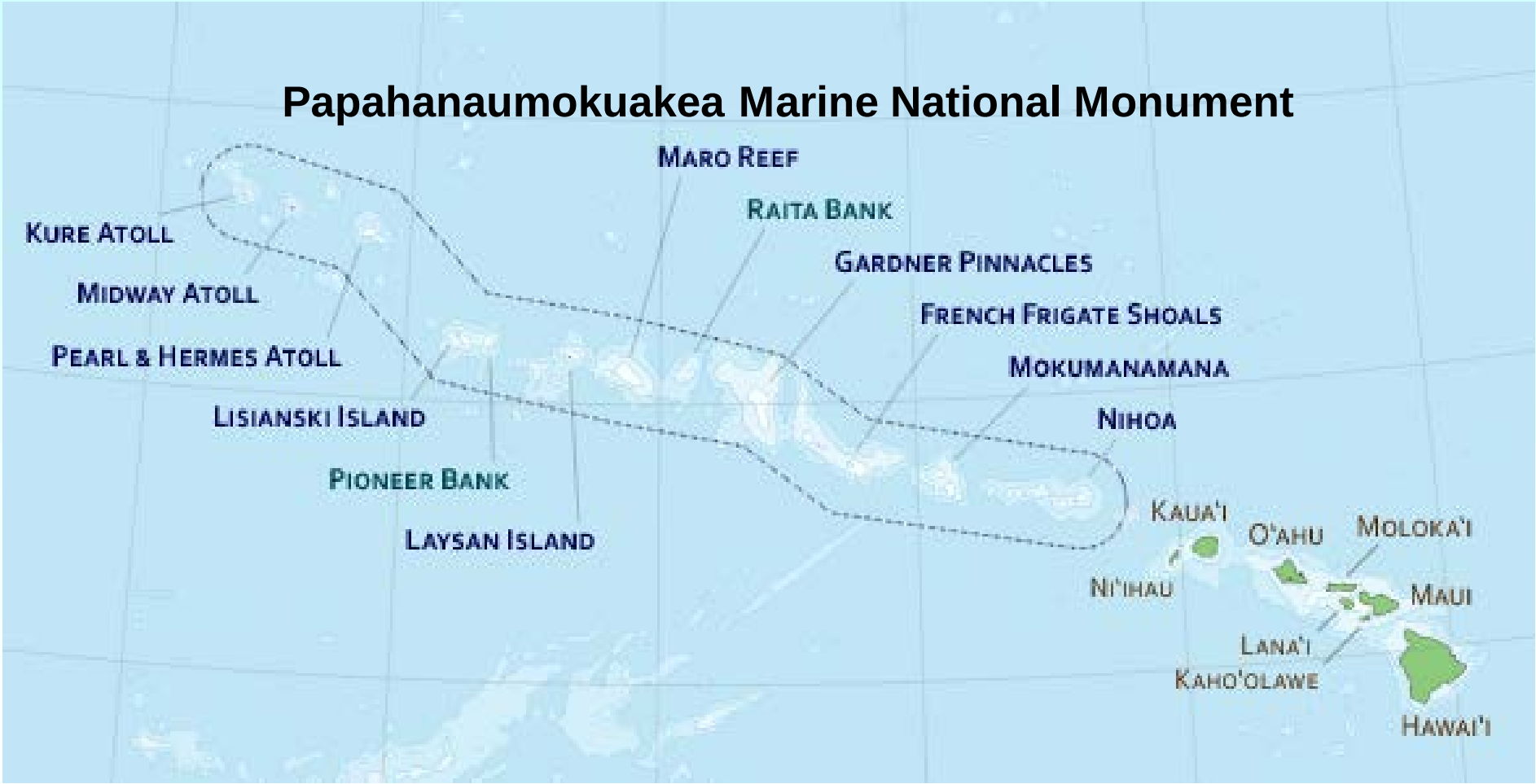


Arctic Shield 2015





August 2015: NWHI Monk Sea and Marine Debris surveys aboard NOAA Ship Sette



362,073 square kilometers of the Pacific Ocean

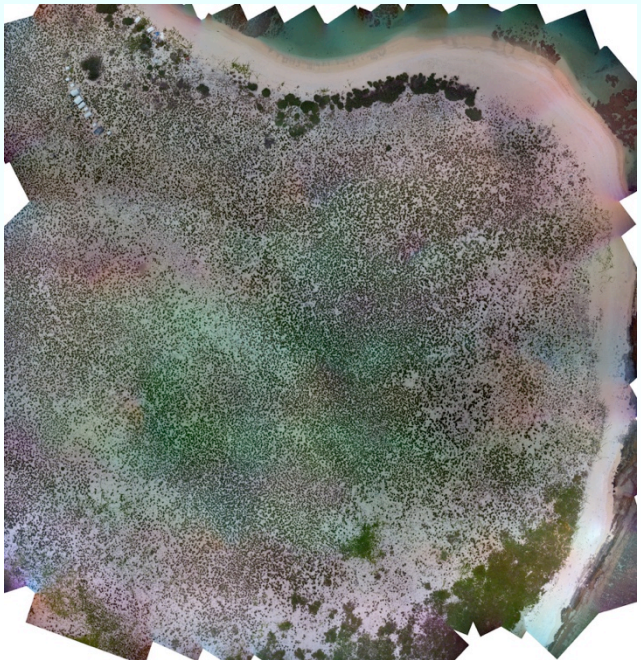
Northwestern Hawaiian Islands

Northwestern Hawaiian Islands

August 2015: NWHI Monk Seal and Marine Debris survey testing and high-resolution mapping

Objectives:

- Surveys for Hawaiian Monk Seal
- High resolution mapping of remote atolls for baseline
- Surveys for marine debris removal teams (lost fishing nets)
- Collecting example data for bird surveys
- Collecting example data for sea turtle surveys

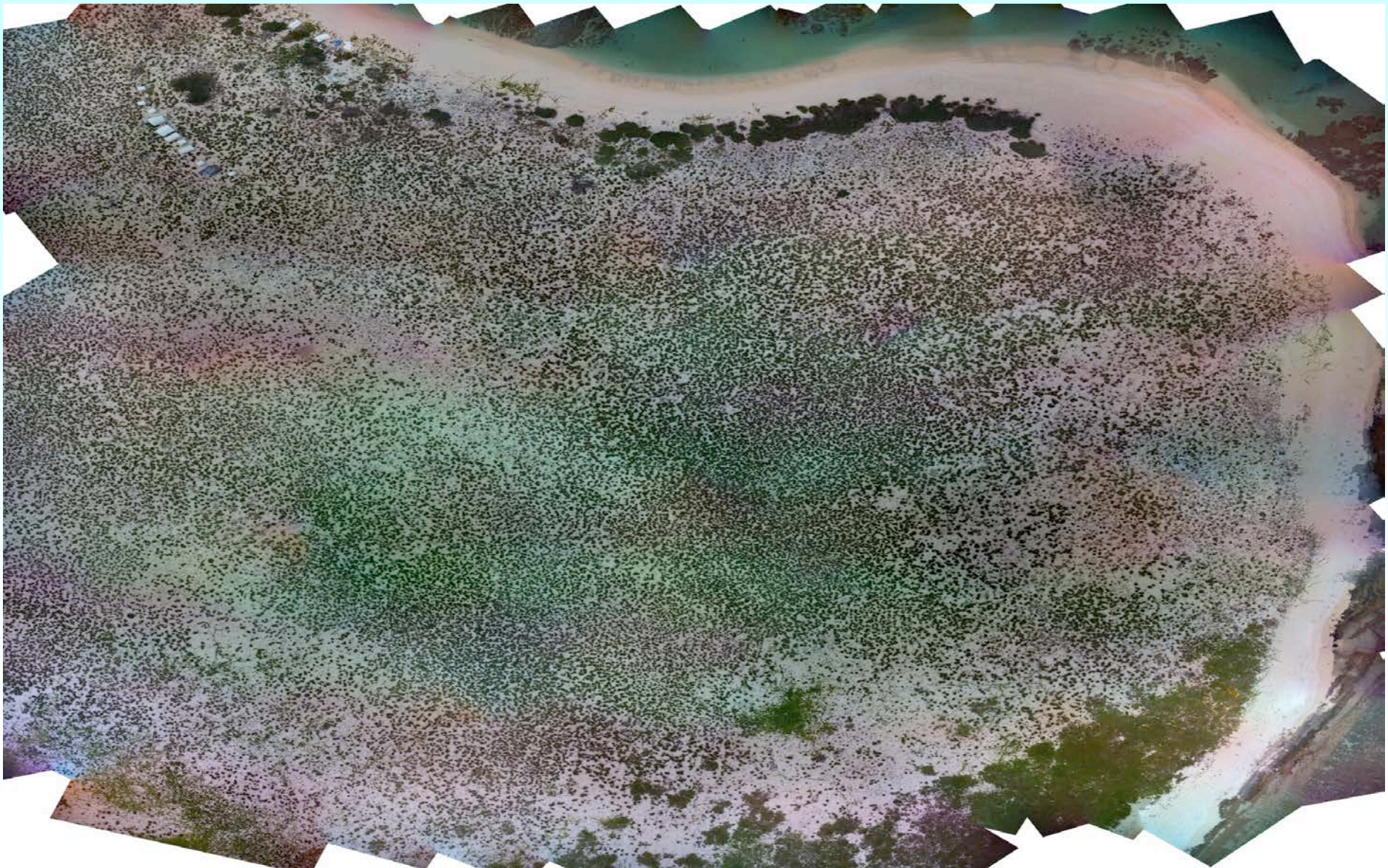


Northwestern Hawaiian Islands

NWHI Monk Seal #207

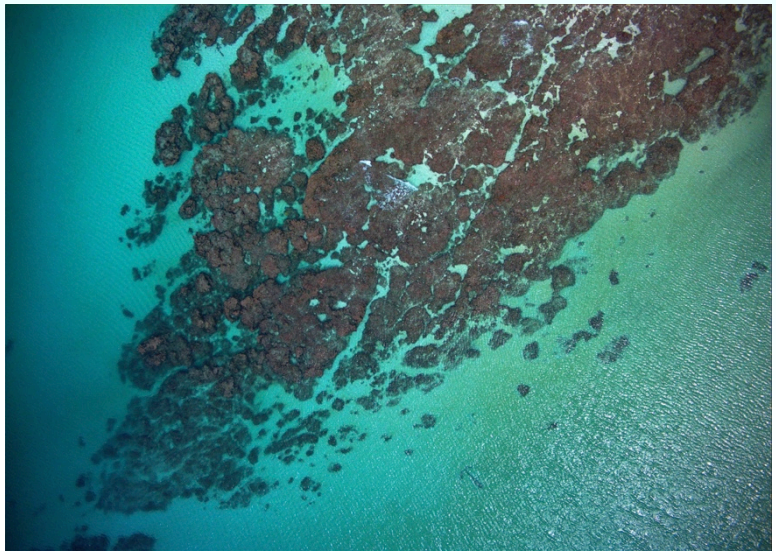
NWHI Green Sea Turtle

NWHI High-resolution Mapping



Northwestern Hawaiian Islands

NWHI Marine Debris and U/W Archeology



Northwestern Hawaiian Islands

November 2015 – February 2016

November 2015:

Testing and documentation of autonomous net solution resolution and range of high-gain patch antenna over water aboard Shearwater in the Santa Barbara Channel in preparation for Operation Deep Freeze 2016 (in support of NOAA and USCG.)

Late December 2016 – February 2016:

ODF-16.

- Flying Puma Block ll BVLOS with long range antennas. Polar test of i45 Super Gimbal.
    - Flying Puma from USCGC Polar Star (Heavy Icebreaker) to provide data to the ship in support of safe and efficient navigation while it is breaking ice during it's mission to open up the ship channel to the McMurdo Research Station for its annual resupply.
    - Collecting of images to provide the National Ice Center (NIC) ground truth for validation of satellite-based forecasts.

November 2015: Long Range Telemetry & Autonomous net capture testing

Testing aboard NOAA R/V Shearwater in the Santa Barbara Channel:

- Sea state 3
- 90+% Success Rate
- All Puma captures ended up in boat without significant damage to airframe or wings.
- This evolved from AS15 and set the stage for ODF-16.

Antarctica

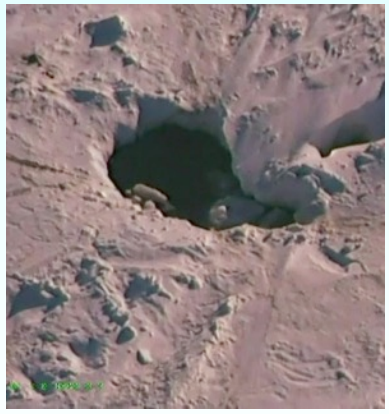
Operation Deep Freeze 2016

- NOAA and USCG
- Annual resupply mission to US National Science Foundation's McMurdo base in Antarctica
- Coordination between National Science Foundation, Department of Defense and US Coast Guard
- Physical and environmental challenges:
- Interesting/impressive statistics:
- Administrative and regulatory challenges: number of organizations involved in planning, review and execution of UAS operations

Deep Freeze Mission Objectives

- Forward scouting for icebreaking
- Collect ice data (images) to validate satellite-based forecasts
- Continue development of shipboard TTPs for small UAS operations in Antarctic and Arctic environments
- Demonstrate effective deployment of small UAS in extreme maritime operations
- Test new Puma UAS i45 camera payload and autonomous net capture system





Operation Deep Freeze 2016

Deep Freeze Achievements

- 20 flights, including
  46 kilometer flight (BVLOS)
  - “12”hours of video
  - i45 high resolution nadir images
- Autonomous shipboard landings
- Concepts of operation developed and tested
- Performed missions in conditions in which helicopters could not operate

Key Requirements for Future Maritime Small UAS Operations

- General maritime operations
  - Pre-programmed operations with more autonomous capabilities for data gathering and recovery
  - High wind capability (greater than 25 kts)
  - Range (BVLOS to 40+ kilometers)
  - Nadir mapping capability
  - Mode C or ADS-B transponder
- Polar maritime operations – most extreme conditions
  - Ice sensing and/or de-icing capability