2012
ONR Naval
S&T Partnership
Conference & ASNE Expo

Assure Access to the Maritime Battlespace

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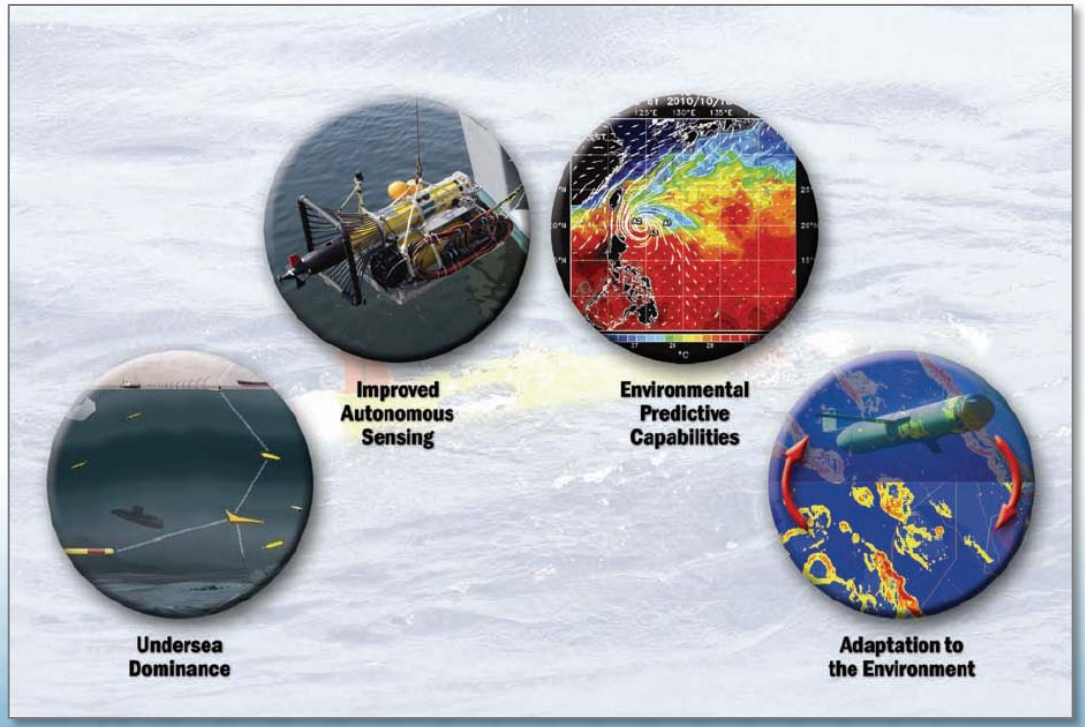
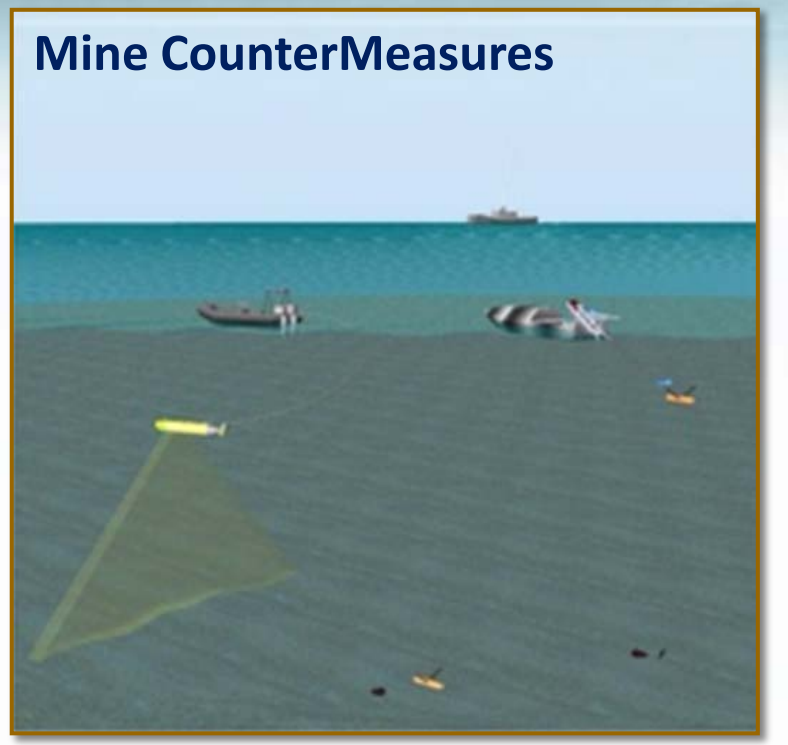
Naval S&T Focus Area:
Assure Access to the Maritime Battlespace

- **Achieve and Maintain Undersea Dominance**
  - Rapid detection and clearing of mines
  - DCLT threat submarines exploiting automation and adaptation to the environment
  - Off-board sensing, cooperative vehicle autonomy, networking and autonomous classification in unmanned systems
  - Next-generation data and target fusion
- **Improve Mobile Autonomous Environmental Sensing**
  - Autonomous sensing of global maritime and littoral environments
  - Adapting environmental sensing strategy to changing conditions
- **Match Environmental Predictive Capabilities to Tactical Planning Requirements**
  - Fully coupled global, regional and local modeling and prediction for operational planning at tactical, strategic and climate scales
- **Maximize Systems Performance via Adaptation to the Environment**
  - Optimize sensing and reduce false alarms



Achieve and Maintain Undersea Dominance



Mine CounterMeasures

Provide rapid, standoff mine countermeasures:

- ***support unencumbered maneuver of combatants, assure access, ensure strategic mobility/sustainment***
- ***decrease the MCM tactical timeline and hazard to ships and Marines, and increase standoff range of combatants from minefields***

Mine / Obstacle Detection

- Increased emphasis on airborne systems for the near surface drifting mine problem
- Clandestine and overt mine and minefield reconnaissance and minehunting
- Technologies for the detection, classification, identification and multi-sensor data fusion of mine and obstacle data

Special Warfare / Explosive Ordnance Disposal (EOD)

- Increase the combat range and effectiveness of Special Warfare and EOD divers
- Autonomous Systems Technologies to increase standoff from threats

Mine / Obstacle Neutralization

- Increase naval combatant safe standoff from sea mines and for rapid mine and obstacle neutralization / clearance for maneuver forces
- Technologies for advanced minesweeping concepts

Mine Technology

- Increasing emphasis
- Asymmetric solutions to counter surface and sub-surface threats
- Technologies for remotely-controlled, UUV-delivered, offensive minefield

Detection and Neutralization of Near-Surface Drifting/Oscillating Mines

Coordinate

- Develop and demonstrate the Compact Modular Sensor / Processor Suite (CMSS)
  - Synthetic Aperture Radar (SAR)
  - Passive Electro-Optic (EO)
  - 3-D Flash LIDAR
  - Real Time Target Recognition Algorithms
- FY12 Start
- Payoff: Capability does not exit today
  - Wide-Area Detection, Classification, Localization
  - In-Situ Characterization of the Environment
  - Onboard Classification: Eliminates Post Mission Analysis (PMA)
  - Low False Alarm Rate (FAR)

Enables Concurrent Detection and Neutralization to Reduce Detect-to-Engage (DTE) Timeline

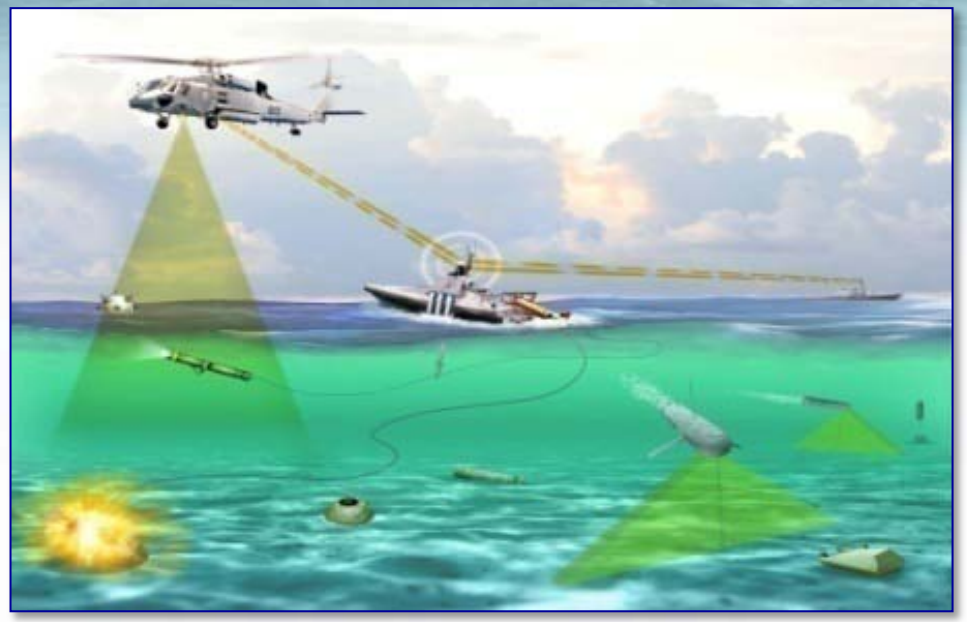
Single Sortie MCM Detect-to-Engage Payload

Objective:

- Payload for common MCM unmanned surface vehicle (USV) that will integrate unmanned underwater vehicles (UUVs) for long range detection and classification, mine identification and mine neutralization.
- Supports automated mission planning and execution, as well as supervised autonomy.

Challenges/Approach:

- Autonomy to manage and coordinate payload components
- Autonomous capability to recharge UUV energy source, perform data management, and re-program next UUV mission
- Capable of launching and recovering heavyweight, lightweight and man-portable UUVs (tethered or untethered), and deployment of man-portable mine neutralizers
- Capable of planning and executing environmentally adaptive autonomous command and control for sequencing search, ID and neutralization
- Capable of underwater and over-the-horizon (OTH) communications that support supervised autonomy



Capability payoff:

- Increased capacity – significantly improved area coverage rate (ACRs)
- Eliminates lengthy post mission analysis, reducing MCM timeline by up to 50%
- Minimizes humans in the minefield
- Adds new capability for non-stationary threats

Anti-Submarine Warfare (ASW)

Hold threat submarines at risk in far forward areas, provide a protective screen to the transiting and MODLOC'ed battle groups, and provide torpedo defense for individual ships.

Mitigate the effects of:

- Decreased **capacity** of theater platforms through development of augmenting off-board sensors and autonomous systems - AUVs, UAVs, floating and fixed sensors, smaller more capable weapons (e.g. multi-warhead), weaponization of UAVs
- Increased **workload** of sailors on platforms through automated signal processing for sonar, synthetic training, and new/improved sensors

Emphasis:

- S&T systems demonstrations developed for all ASW missions: **I&W intelligence, surveillance, search, localization, tracking, engagement, undersea weaponry, torpedo defense, training**
    - Developments address "anti-access" fight
    - Exploit environment to tactical advantage

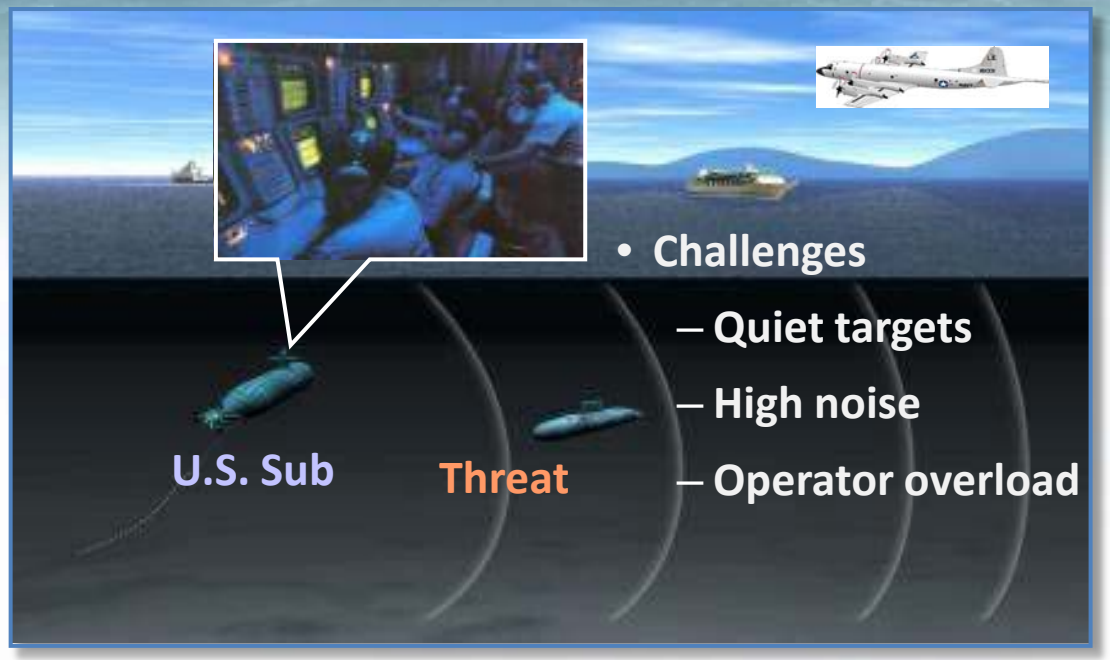
Indirectly supported by:

- Operational Environments basic/applied research
- Marine Mammal studies to ensure environmental compliance and enable broader ASW training

Sonar Automation

Description:

- Develop and demonstrate technologies to advance the automation of active and passive sonar systems
- Advanced active classification algorithms will be applied to active sonar systems
- Individual source signals will be isolated prior to classification in passive sonar systems through the application of advanced algorithms
- Result will be the ability of operators to handle more receivers in active systems and more beams in passive systems with large arrays



S&T Focus:

- Develop advanced algorithms designed to separate broadband and narrowband signals detected by source prior to classification
- Develop robust classification algorithms that do not require prior identification of target or track features to include “featureless” classifiers and “deep learning” algorithm development
- Development of state-of-the-art feature extraction techniques for improved target/clutter discrimination based on multiple waveform feature association

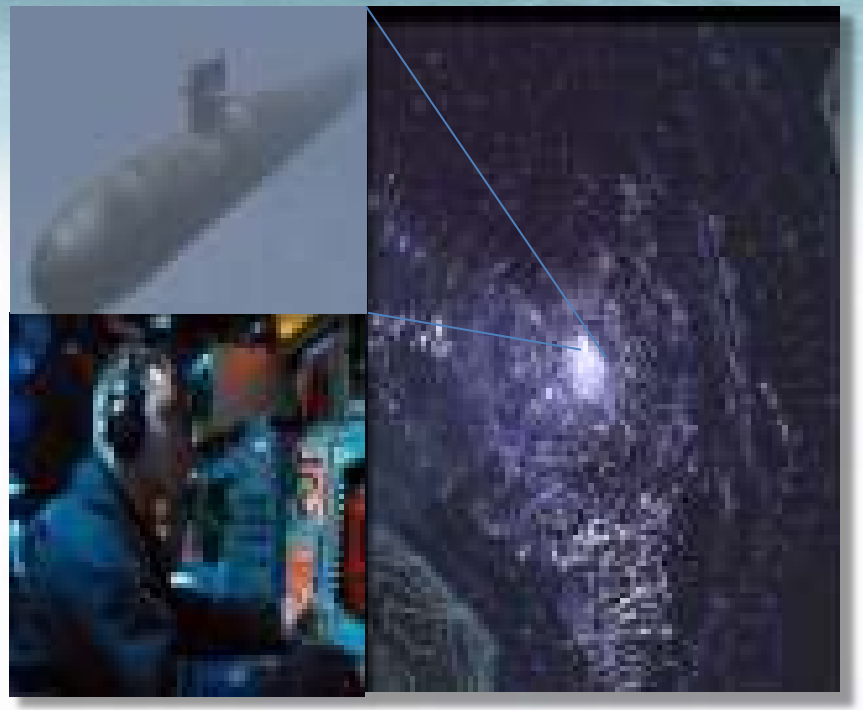
Payoff:

- Improve sonar system performance
- Reduction of operator workload
- Acceleration of operator acoustic training phase
- Increase operator training opportunities

ASW Synthetic Training

Description:

High fidelity, computer-based active sonar simulations for operators (both surface and air platforms) with a linked training architecture that supports integrated cross-platform ASW training from the operator to the ASW Commander level



Research Challenges and Opportunities:

- Development of high fidelity models for target strength, reverberation, and various clutter types
- Development of synthetic, performance degradable, modeling that reacts realistically to changing tactical situations and the environment
- Design, development, and integration of a non-linear algorithm that maximizes coverage while minimizing mutual interference under defined operational conditions
- Model intelligent behavior that replicates diesel electric submarine tactics

Warfighter Payoff:

- Improved team training for integrated (surface and air) sonar operations in the detect-to-engage sequence
- Increased training opportunities for highly perishable ASW skills

Next Generation Multi-Static Active Capability (NGMAC)

Objective:

Develop and deliver improved source and receiver sonobuoys and algorithms that will

- enable the Multi-Static Active Coherent (MAC) program to maintain coverage of a field of sonobuoys as well as
- keep the area of uncertainty (AOU) of a signal of interest from growing

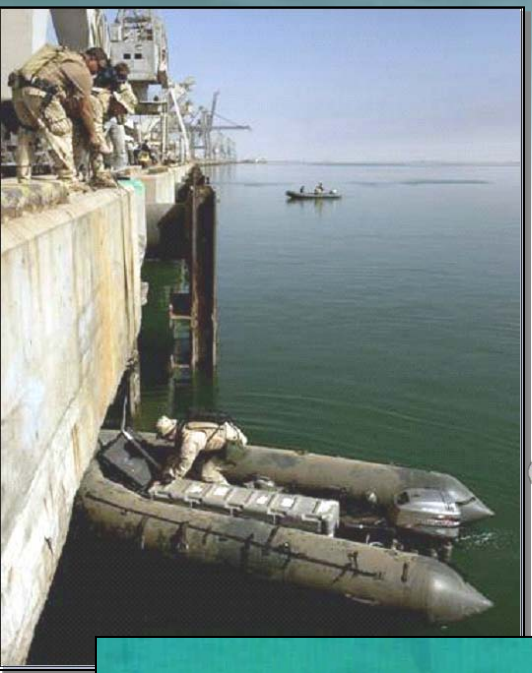
Technical Challenges:

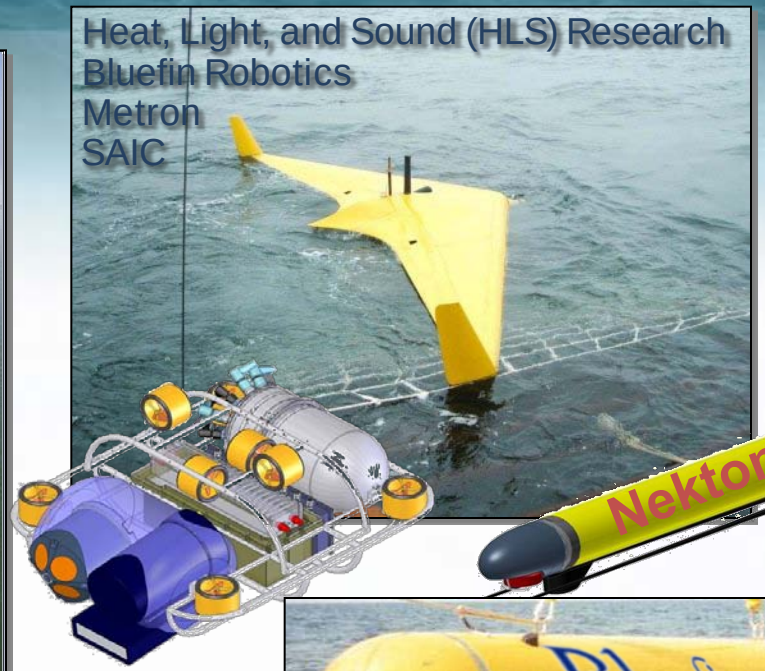
- Addition of GPS to A-size sonobuoy
- Advancements to in-buoy signal processing
- Higher power requirements

Payoff:

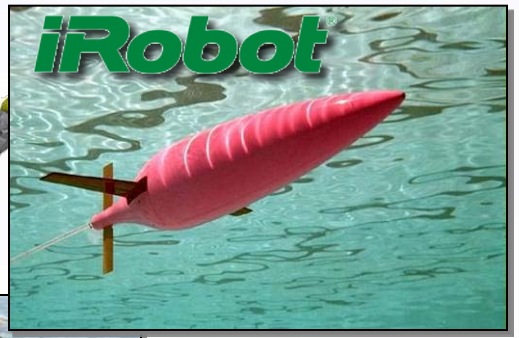
Extended life MAC sonobuoys with higher source level and enhanced state estimation algorithms that reduce the detect-to-engage timeline in submarine prosecutions

Autonomous Sensing
for MCM, ASW, and Environment





- **Networked, mobile, persistent, scalable**
- **Intelligence Preparation of the Battlespace – before all platforms**

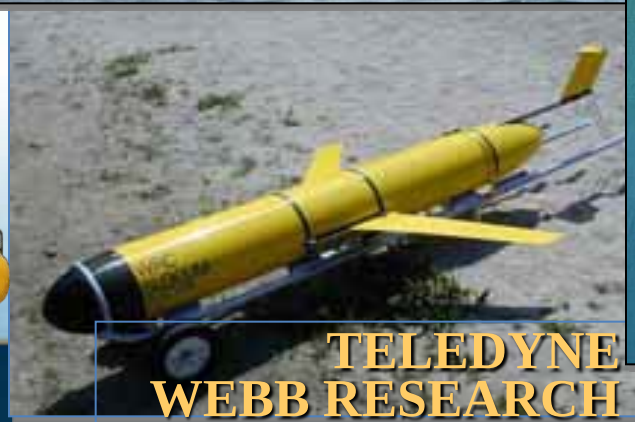


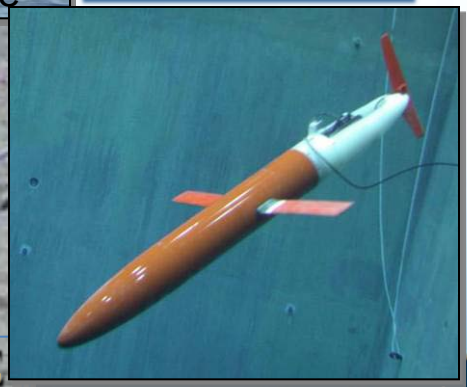
Battelle

BLUEFIN ROBOTICS

Florida Atlantic University
Advanced Marine Systems Lab

Kongsberg Maritime





TELEDYNE
WEBB RESEARCH

S&T Developments in Man Portable and Light Weight UUVs Technology

Improved Navigation
- Low power INUs for UUVs
- USBL Navigation
- Robust DVL/ADCP

- Low Power Navigation
- FBN

Control & Autonomy
- UUV JAUS Standards
- ASTM F41 Architecture
- Hierarchy Autonomy
- Behavior Autonomy
- Obstacle Avoidance
- Onboard CAD/CAC
- Anti-Tamper
- CfN Mission Planning
- Precision Positioning

Launch & Recovery
- USV L&R
- Autonomous RHIB L&R
- Ship L&R
- Submerged L&R / Docking Station

Platform Improvements
- Net Cutting
- Autonomous Recovery
- Forward Fin Module
- Hovering Module
- Anchor Module
- Ballast Module
- Payload Delivery Modules

Modularity
- Standard Interfaces
- Flooded or Dry Payload Sections
- Expandable Payloads

Communications
- Acoustic Comms
- Fast RF Comms

Sensors
- Marine Sonics DF Sidescan
- EdgeTech Sidescan
- SSAM DF
- RTG / LSG
- ASW
- ATLAS FLS

- LF sensors
- Video w/LED Bar
- Blazed Array Sensors
- Environmental Sensors
- Chemical Sensors
- BOSS

Propulsion
- Low Noise & Power Motors

Power Systems
- Li Ion Batteries
- Safe Pressure Tolerant Li Ion Batteries
- High Endurance Power Tow Module

Large Diameter Unmanned Undersea Vehicle

Naval Strategic Priority

Reliable:

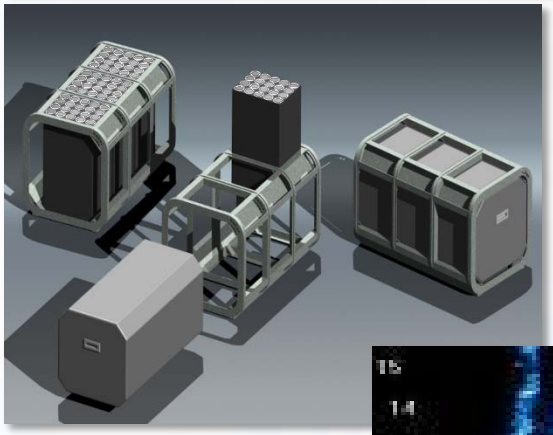
- Long Endurance UUV capable of 60+ days of operation in the Littorals
- Operate in complex ocean environment near harbors, shore, and high surface traffic locations

Energy:

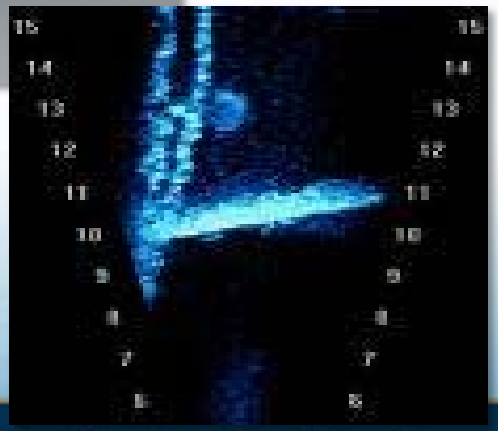
- 5x – 10x Current UUV Energy Density
- Extends and multiplies the reach of the platform into denied areas and reduces platform vulnerability
- Open Ocean/Over the Horizon Operations

Autonomy:

- Enables realization of fully autonomous UUVs operating in complex near shore environments to increase capability
- Cost effectively closes war fighter capability and capacity gaps in critical mission areas



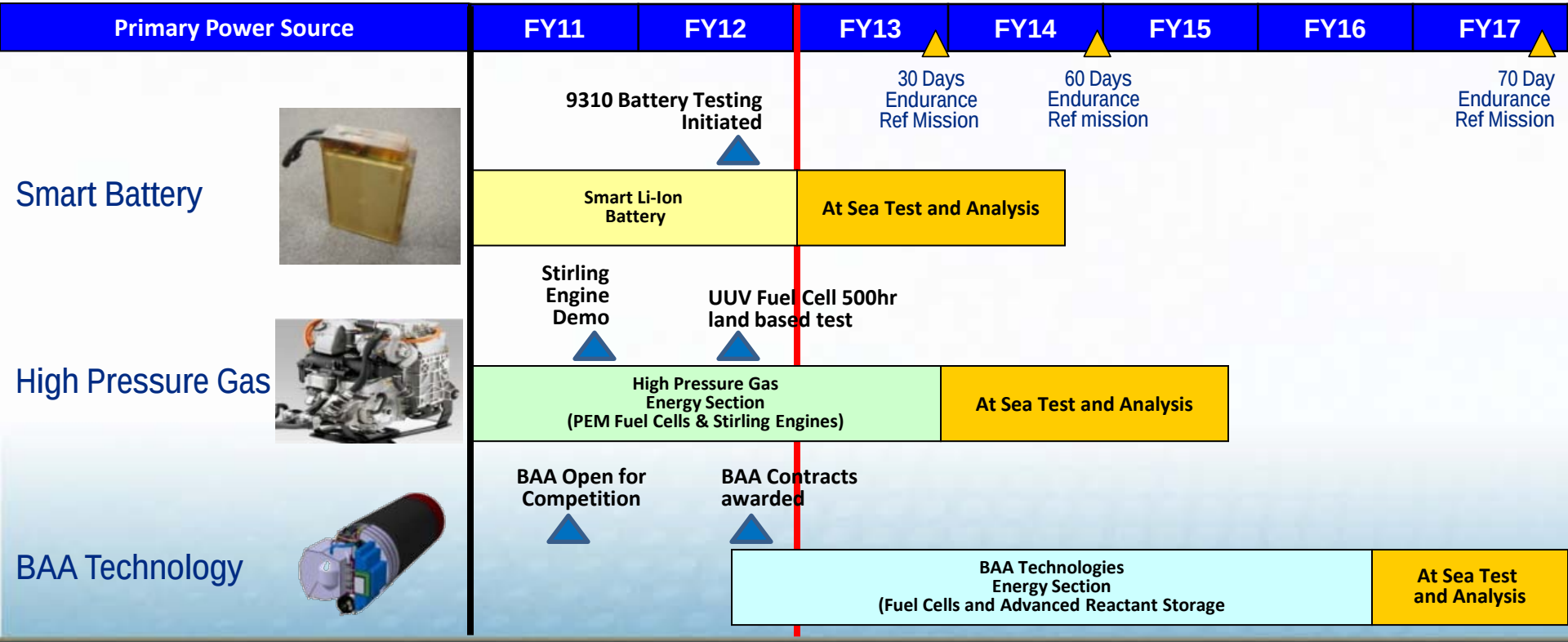
Open Architecture Modular Payloads



Autonomous Operation

LDUUV INP Energy Plan

The **Large Displacement Unmanned Undersea Vehicle Innovative Naval Prototype (LDUUV INP)** program will develop autonomous, long-endurance, land-launched unmanned undersea vehicles capable of operating near shore



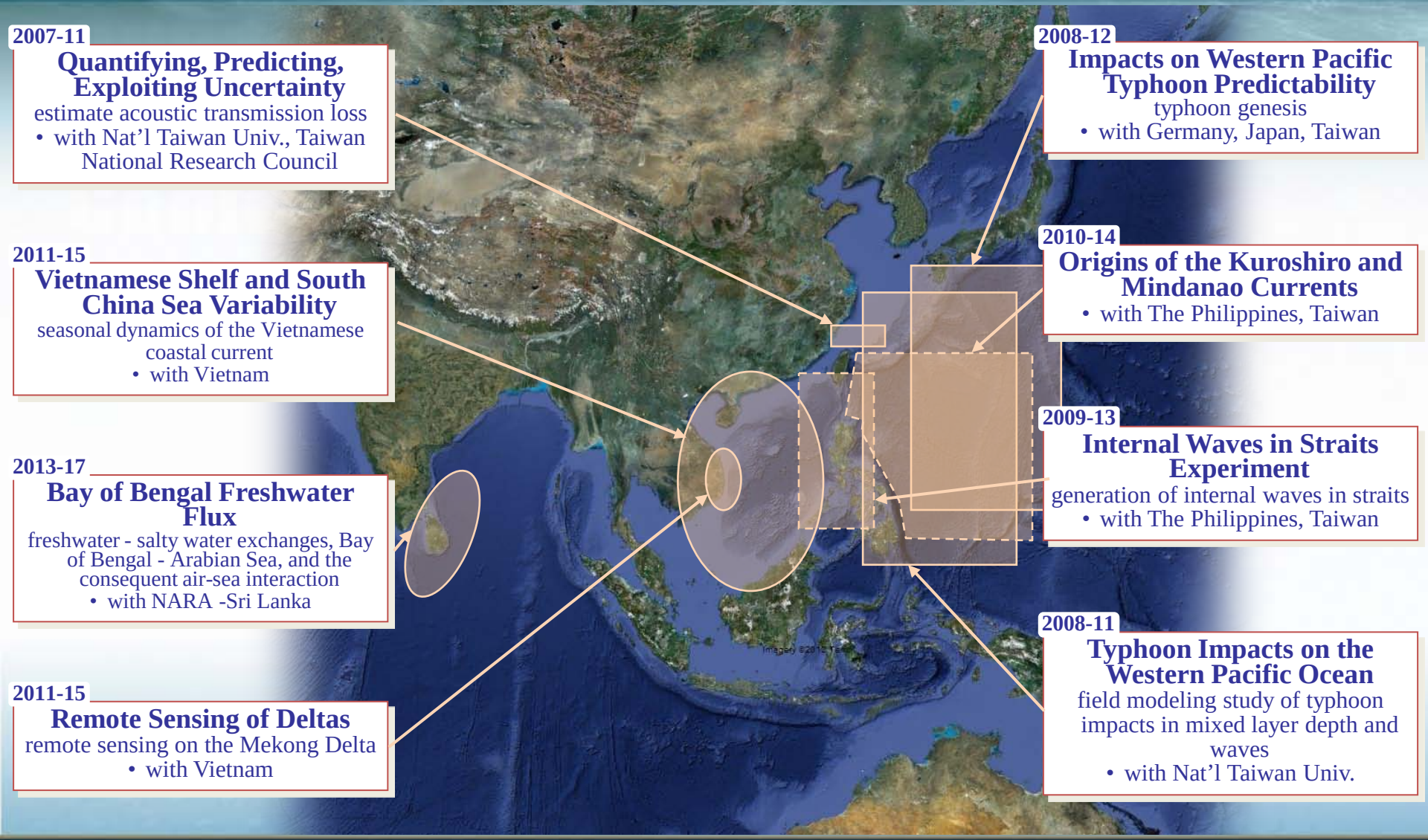
Environmental Sensing, Prediction, and Adaptation

GOAL: Exploit the environment to our tactical advantage by accurately predicting and adapting to the ocean, air, littoral and riverine environments on tactical and strategic time scales

Three Important Thrusts:

- **Mobile autonomous environment sensing**
- **Match predictive capabilities to tactical planning requirements – tactical and strategic**
- **Adapt systems to environmental variability**

WESTPAC & IO Operational Environment



2007-11
Quantifying, Predicting, Exploiting Uncertainty
estimate acoustic transmission loss
- with Nat'l Taiwan Univ., Taiwan National Research Council

2011-15
Vietnamese Shelf and South China Sea Variability
seasonal dynamics of the Vietnamese coastal current
- with Vietnam

2013-17
Bay of Bengal Freshwater Flux
freshwater - salty water exchanges, Bay of Bengal - Arabian Sea, and the consequent air-sea interaction
- with NARA -Sri Lanka

2011-15
Remote Sensing of Deltas
remote sensing on the Mekong Delta
- with Vietnam

2008-12
Impacts on Western Pacific Typhoon Predictability
typhoon genesis
- with Germany, Japan, Taiwan

2010-14
Origins of the Kuroshiro and Mindanao Currents
- with The Philippines, Taiwan

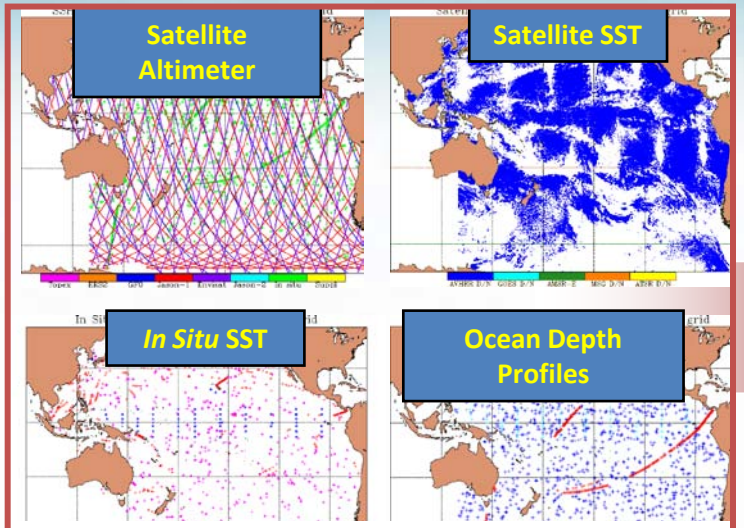
2009-13
Internal Waves in Straits Experiment
generation of internal waves in straits
- with The Philippines, Taiwan

2008-11
Typhoon Impacts on the Western Pacific Ocean
field modeling study of typhoon impacts in mixed layer depth and waves
- with Nat'l Taiwan Univ.

Development of the Hybrid Coordinate Ocean Model (HYCOM)

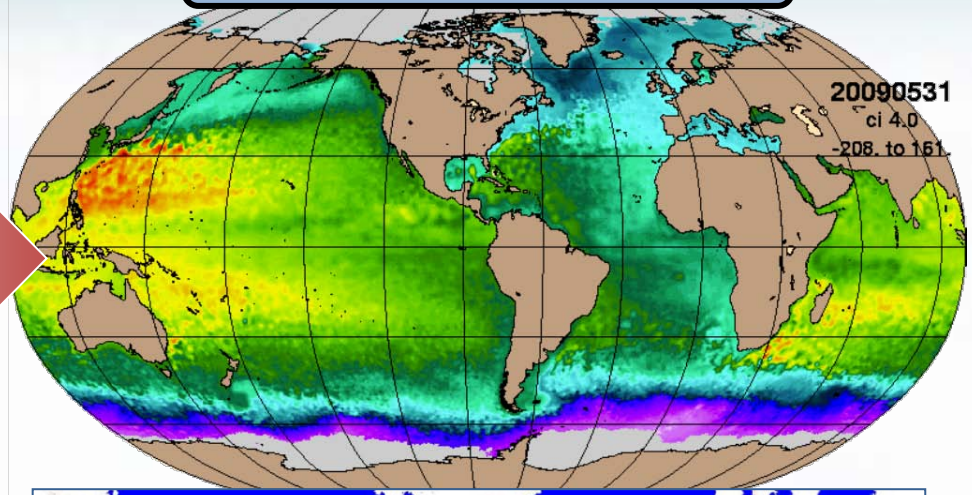
A Component of the Nation's Next Global Operational Prediction System

The HYCOM numerical model and data assimilation system have been developed to provide daily to weekly forecasts of the global ocean conditions at high (~3km) horizontal resolution. The model employs a unique hybrid vertical coordinate system, and is a product of a joint Navy, NOAA, and academic research team.



Observations of the Ocean

Predicted Ocean State



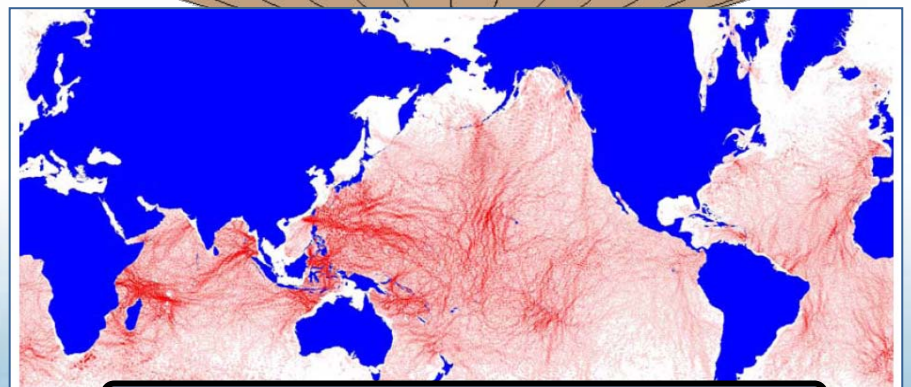
FY10: Completed HYCOM Global Ocean Forecast System 3.0, Phase II for transition to NAVO

FY11: Coupling of ocean physics with sea ice model to provide Arctic prediction capability

FY12: Test real-time operation of 1/25° global ocean model, including tides and LANL's sea ice model

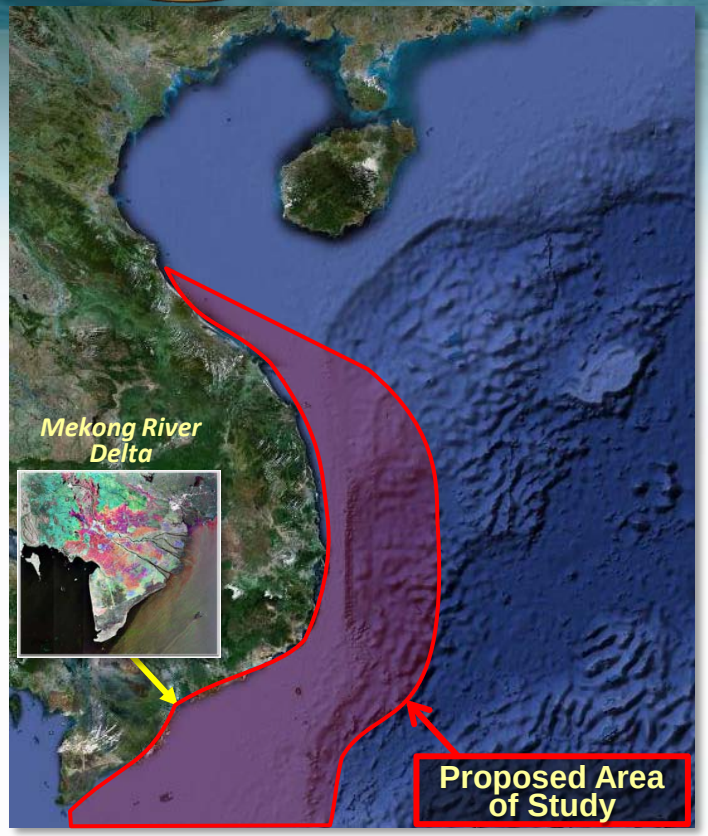
FY13: Downscaling of model to nested regional domains for higher-fidelity local modeling

FY14: Model validation and verification using in situ ocean data sets



M2 tidal amplitudes from a 32-layer HYCOM run

The Structure, Circulation, and Variability of the Vietnamese Shelf and S. China Sea DRI



Objective/Plan:

- Study Physical Oceanography and Interactions in the Vietnamese East Sea (2012-2016)
- Joint oceanographic research will be performed by US academic scientists funded by ONR and Vietnamese scientists funded by the Vietnamese Ministry of Science and Technology to address common research issues in the Vietnamese East Sea (South China Sea)

Scientific Goals:

- Achieve a better understanding of the complex oceanographic processes operating in this region
- Understand how variability in monsoon forcing may impact the Mekong Delta and Vietnamese East Sea
- Learn how outflow from the Mekong and other rivers alter the structure, circulation, and sediment dynamics of the Vietnamese East Sea
- Build an integrated predictive model for the Vietnamese East Sea

Outcomes of the Cooperative Effort:

- Enhanced mutual understanding between Vietnam and the U.S. through training courses and student exchanges
- Improved scientific collaboration between scientists from both countries
- Updated databases and observing systems for the East Sea
- Generation of new knowledge about the ocean
- Joint US-Vietnamese publications in the scientific literature

Effects of Bay of Bengal Freshwater Flux on Air-Sea Interaction (EBOB) DRI

Objective: To determine the dominant processes governing the freshwater distribution including fresh and salty water exchanges between Bay of Bengal and Arabian Sea and the consequent air-sea interaction

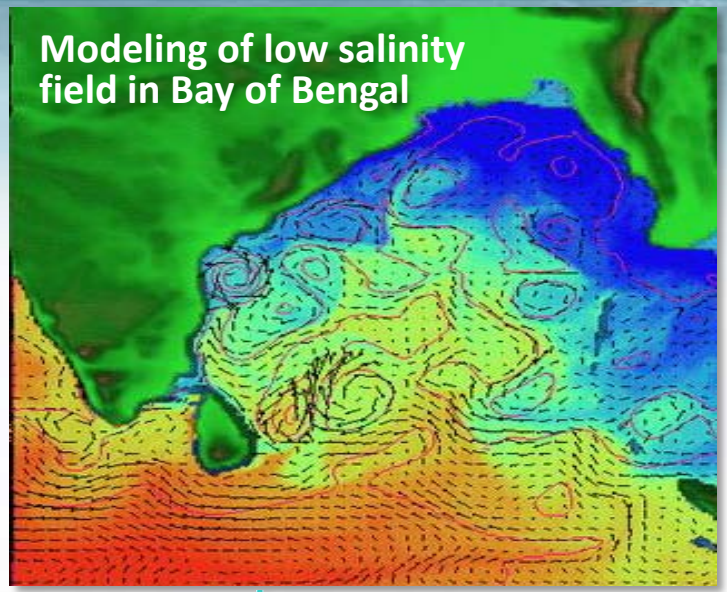
Payoff:

- Improving predictability of North Indian Ocean Circulation and Indian Monsoon
- Characterizing oceanographic data sets for navy applications
- Builds/begins research base in Indian Ocean in collaboration with Sri Lanka while establishing links with India

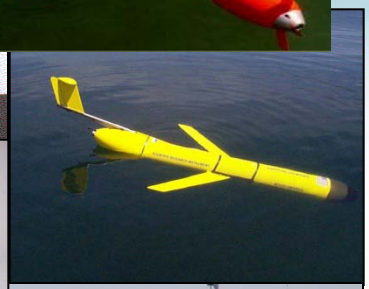
Approach:

- Conduct a field program over regions of east of Sri Lanka shelf/slope to open Indian Ocean in conjunction with air-sea coupled model simulations
- Detailed physical processes (advection, mixing, eddy activity, internal/Rossby waves) will be examined through analysis of field measurements and model simulations

Partnerships: ONR, NRL, NARA -Sri Lanka, Interagency, International



Assure Access to the Maritime Battlespace



Points of Contact are listed at:

- The Assured Access kiosk
- the Prince William room
- the ONR website