

An IOOS Operational Wave Observation Plan



Supported by NOAA IOOS Program & USACE



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JCOMM-Workshop on Wave Measurements from Buoys

Wave Information to Application

Observations

Models

Societal Goals

Offshore &
Outer Shelf



Inner Shelf
& Coastal



Surf



Beach

Waves: Directional Buoys	Regional Wave Prediction	<ul style="list-style-type: none"> • Safe and efficient Maritime Operations • Natural Hazards (hurricanes)
Waves: Directional Buoys Waves: PUVs	Nearshore Wave Prediction	Public Health Coastal Engineering and Planning
Directional Buoys Pressure sensors PUVs	Surfzone Wave & Current Prediction	Beach Safety (rips) Public Health Natural Hazards (Inundation)
Directional Buoys Pressure sensors PUVs + Beach Surveys	Sediment Transport Prediction	Beach Change (Coastal Evolution w/ Climate Change)



Information Flow



Wave Measurement Plan: Historical Perspective

- From the 1970's – early 2000's
 - Short term field experiments
 - US assets were positioned and exclusively for the NWS
 - **Meteorological measurements ONLY**
 - NDBC foresight: add wave measurements
 - NDBC / USACE: add directional capabilities
 - USACE: Coastal Data Information Program (CDIP-SIO)
- Past and Present Assets
 - Positioning **ad-hoc**
 - Based on funding, availability and local requirements

NEED TO STEP BACK AND DEVISE A NATIONAL WAVES PLAN



Waves Plan: Objectives

- An integrated plan for wave measurements in the US addresses
 - Spatial / temporal coverage
 - Accuracy requirements of wave information
- Establish requirements for existing assets; identify gaps / upgrades
- Wave Observing System Design

Four Subnets: Offshore / Outer / Inner / Coastal

- Integrate wave measurement assets via NDBC (24/7 operations)
- Technology development, training activities
- Testing and evaluation of existing and new technologies
- Long-term sustainable measurement program

Have plan in place “before” there’s a significant expansion of IOOS observation capabilities



Existing Wave Observation Sites

Table 1. Summary of Existing Non-Directional, Directional Platforms

Region	12 m & 10 m Discus	6-m Discus	3-m Discus				Other Buoy Configurations					Shallow	
			Hippy	Angular Rate	Magnetometer	Strapped Down Accelerometer	2.0 m	1.8 m	1.7 m	1.1 m	Waverider	Pressure	Acoustic
Atlantic Coast 1D	2	12(1)				8	11					2	
2D			2	6				5		1	4	1	8
Gulf of Mexico 1D													
2D	5			2	5			4			1		5
Pacific Coast 1D	2	4(1)				9						1	
2D			5	8							21		
Alaska 1D	2	14(2)				2(3)							
2D								3					
Pacific Islands 1D		3											
2D			1								2		1
Great Lakes 1D						3(6)			(2)				
2D				1	5								
Caribbean 1D	2	6											
2D													
TOTAL	13	39(4)	8	17	10	22(9)	11	12	(2)	1	28	4	14

IS GROUND TRUTH BECOMING A SLIPPERY SLOPE ?

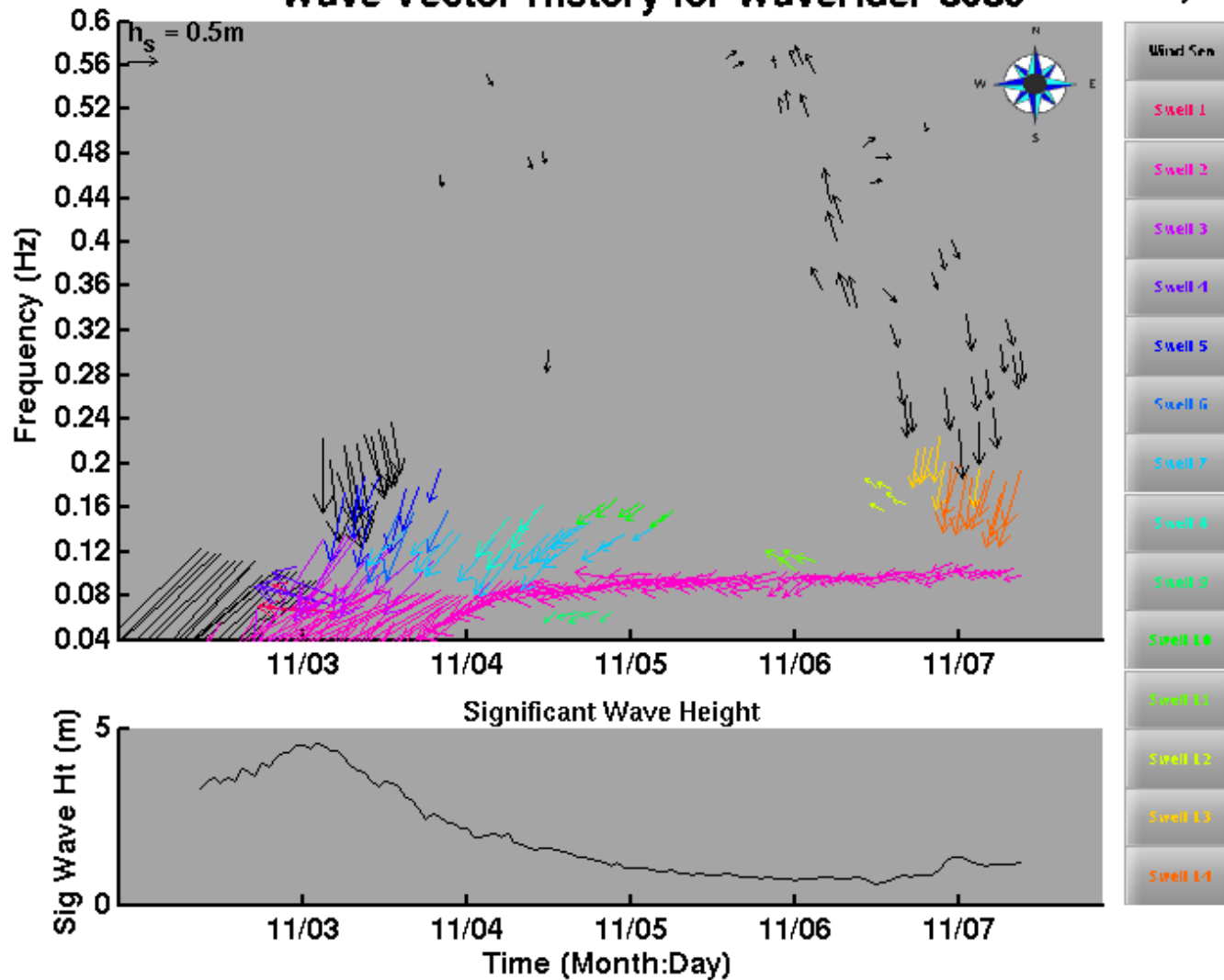
Wave Measurement Plan: First-5 Metrics

- Direct measurement of the free surface
 - Wire Resistance
- Indirect measurements
 - HIPPY Sensors
 - Axial (3-D) accelometers
 - Acoustic Profilers
 - Pressure transducers (PUV's SXY's)
 - HF, X-Band Radar Systems
 - Altimeters, SAR's
- Particle- Slope- Following
- **What is Ground Truth?**
 - Nearshore applications ($h < 20\text{m}$)
 - Deep Water ($h > 20\text{m}$)



Wave Vector History for Waverider-3630

Wave Systems



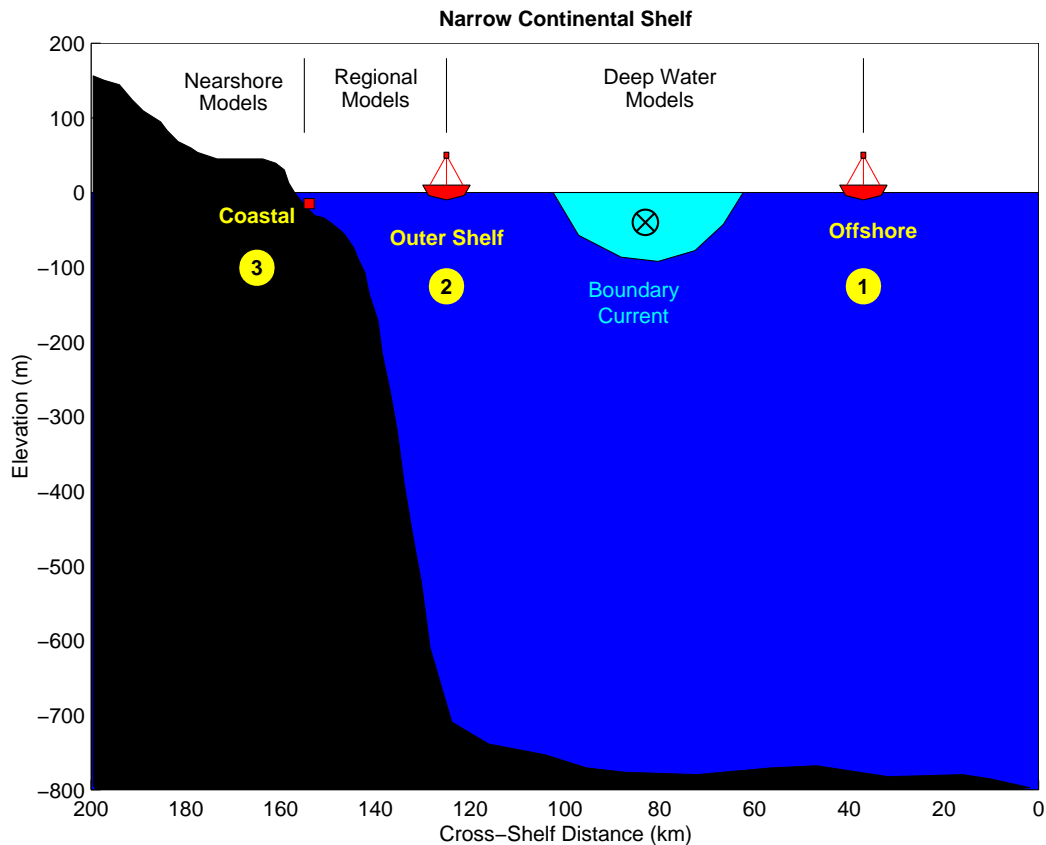
Goal is an in-situ network, providing “First-5” estimates of the directional wave field
(First-5 is the minimum number of coefficients that are required to define the major wave trains in a complex wave field)

Approach and Implementation

- Accuracy Requirement – “First-5” Capability
 - Defines the minimum number of variables required to define the directional wave field.
 - Recognizes the challenge of resolving complex directional wave fields
- Data Integration Framework
 - Integrate what exists, develop common formats, products, etc.
 - Flow all data through Data Assembly Centers
- Test & Evaluation (T&E)
 - Critical requirement to evaluate existing platforms to see if they meet First-5 standard.
 - This is an initial focus; don’t want to expand network with untested sensors
 - Good role for the Alliance of Coastal Technologies (ACT)
- Sequence
 - Schedule, priorities, and costs most specific for initial years; process-oriented in later years
 - Plan is a dynamic document, revisited as plan is implemented
 - Need to fully engage partners/stakeholders on locations, sensors, data flow
- Funding: Plan will depend on a collaborative funding model
 - NDBC, USACE, Regional Associations, others
 - Plan defines the “Gap” between what exists and what should exist
- Upgrades, new locations, new infrastructure
 - Planned system will be a significant improvement over the existing, ad hoc system
- Emerging Technologies – support new technologies as they develop (radar, satellite)



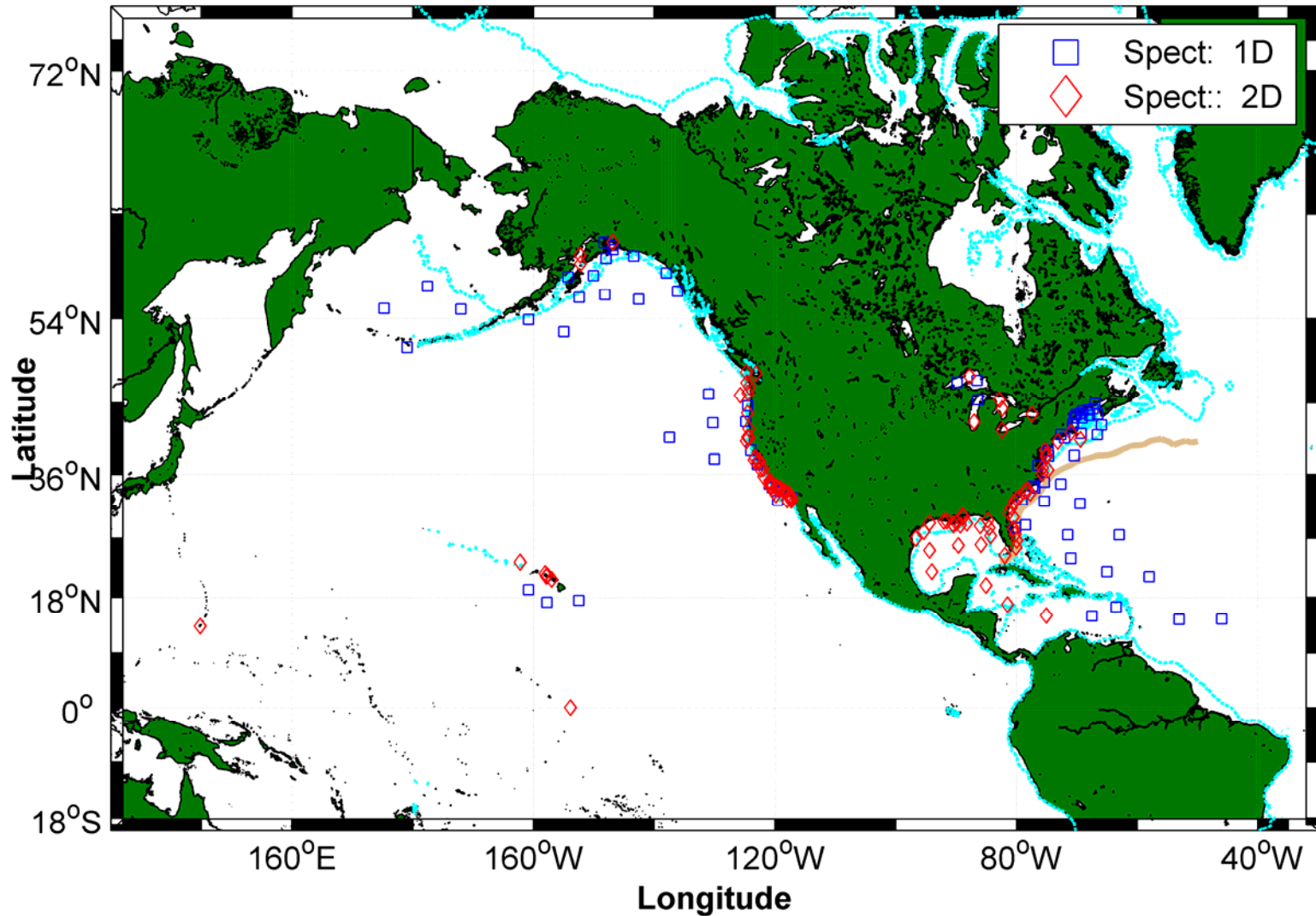
Wave Observation Network: Design



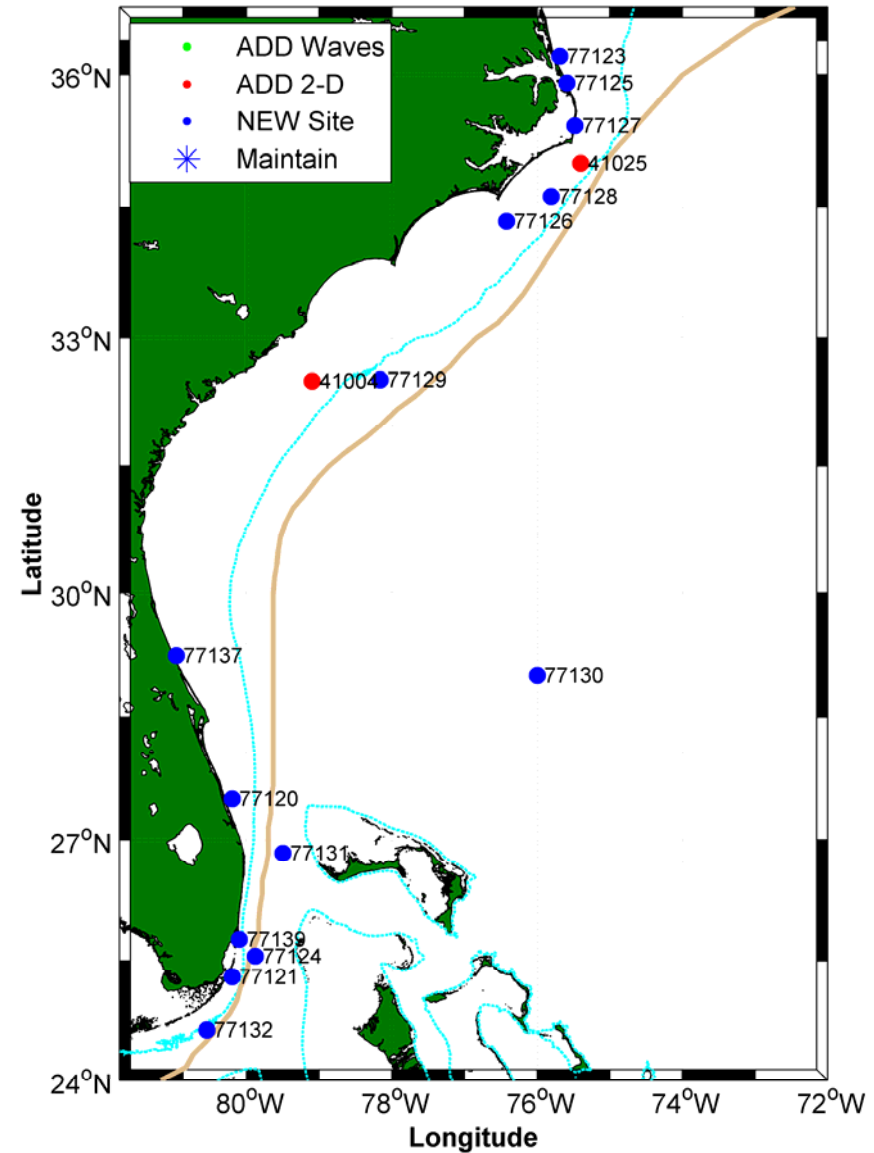
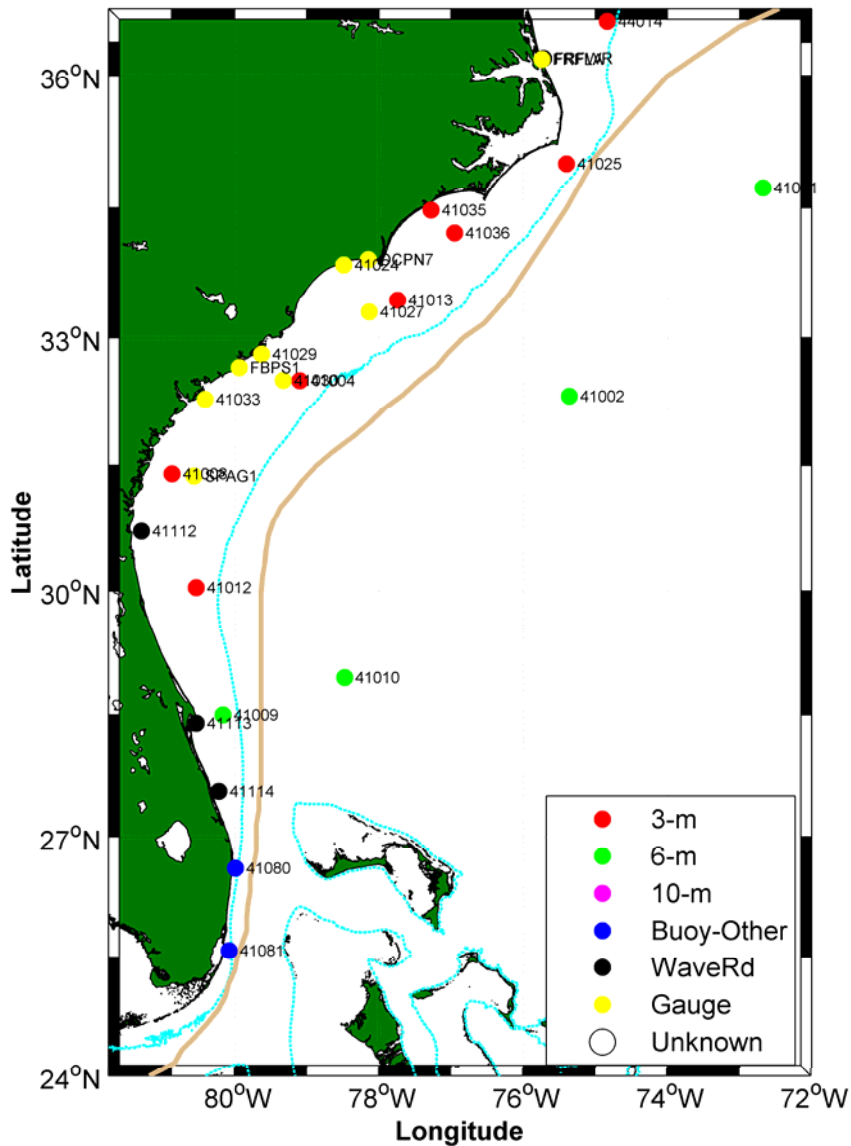
- **Offshore Subnet:** deep ocean outpost stations provide an early warning (~ 1 day) of developing storm wave conditions;
- **Outer-Shelf Subnet:** an array along the edge of the continental shelf, where waves begin to transition from deep to shallow water;
- **Inner-Shelf Subnet:** on wide continental shelves, an array of shallow water (20-30 m depth) stations to monitor cross-shelf bottom dissipation and wind generation of waves
- **Coastal Subnet:** a set of shallow coastal wave observations which provide local need-driver site-specific information.

This approach aligns with the domains used in global, regional & nearshore wave models, and because of the coverage, supports all other wave data users

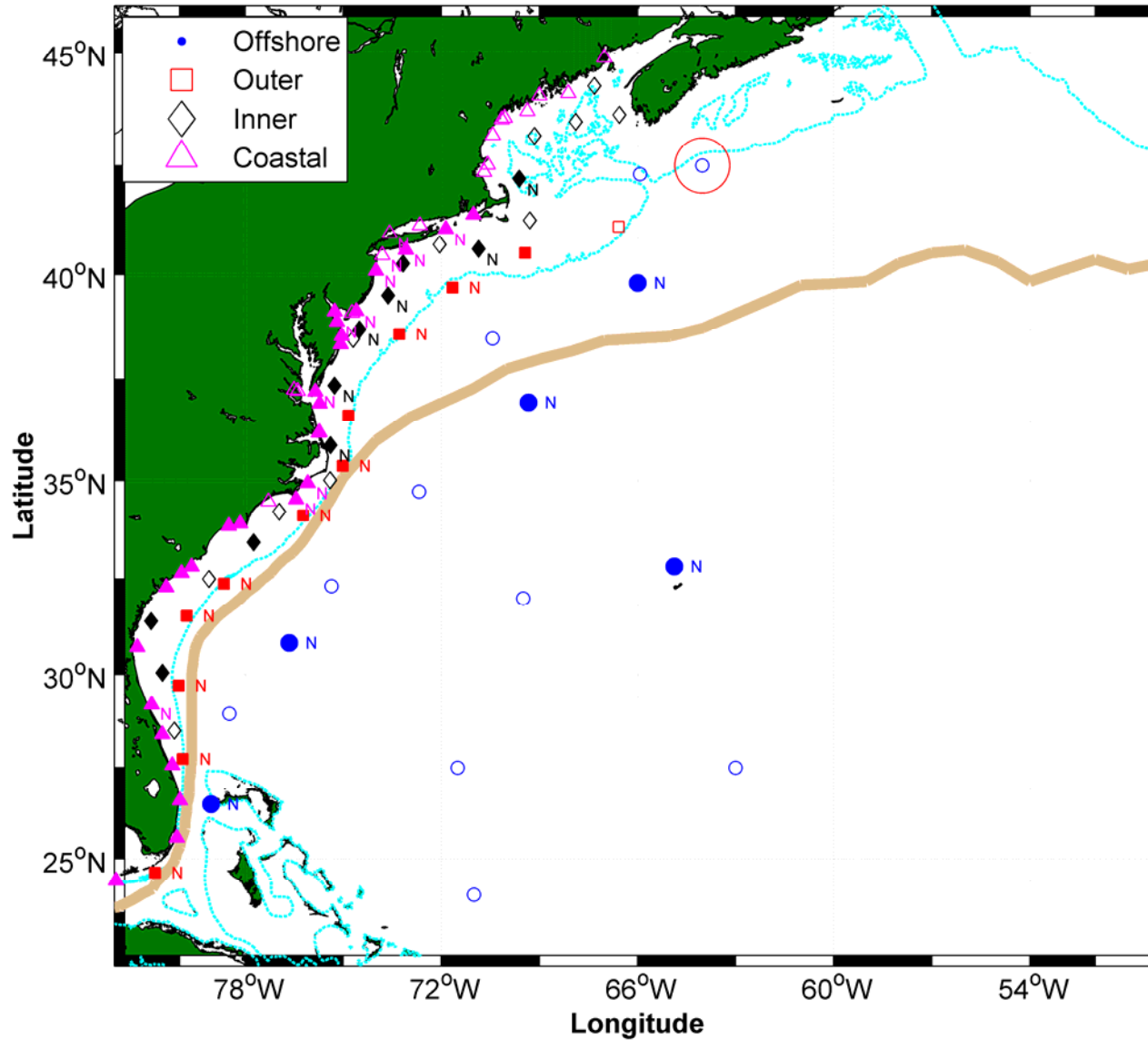
Existing Observations: Total = 184



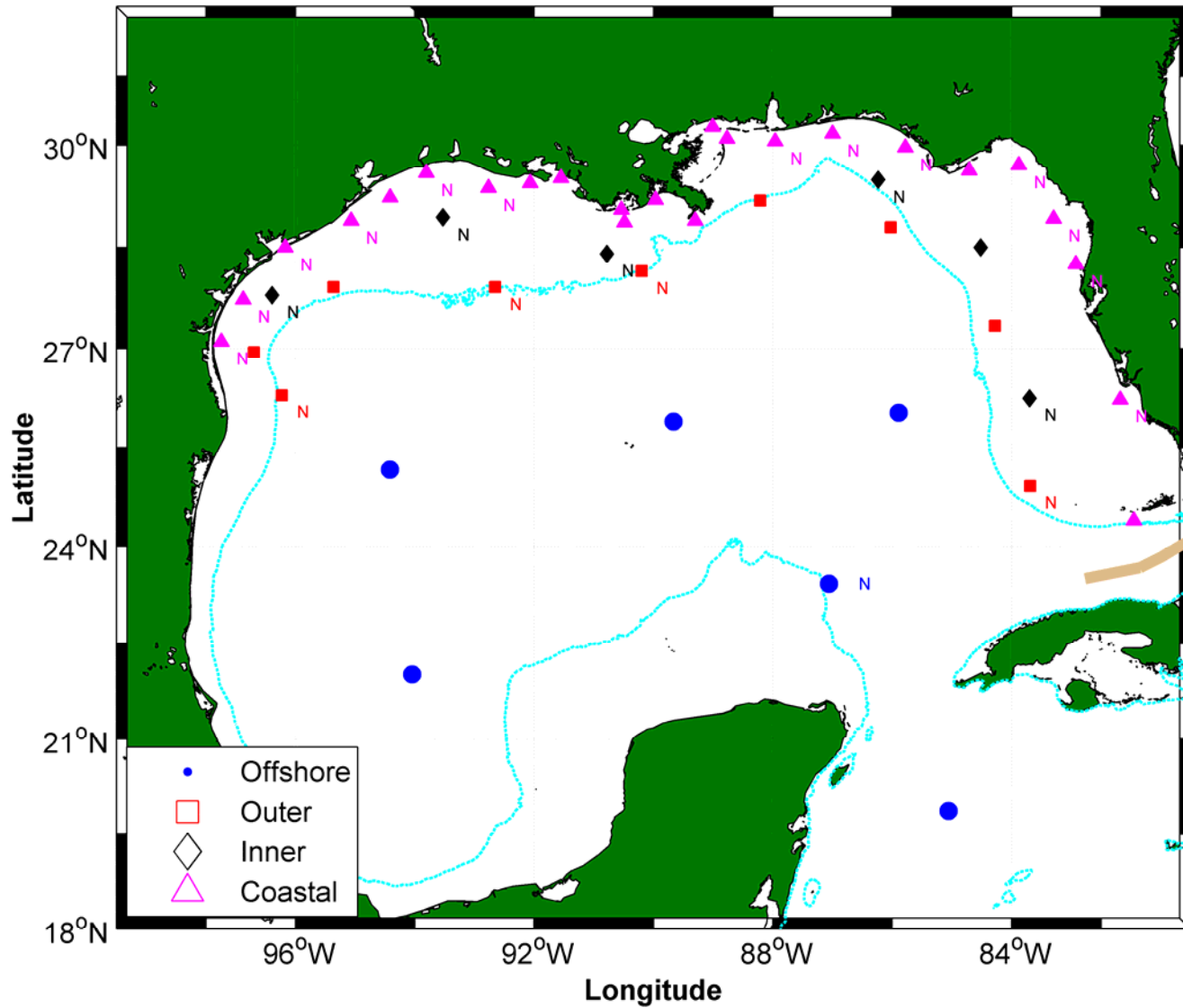
SECOORA Existing / Requested Sites



Atlantic Coast: Existing and New



Gulf of Mexico: Existing and New



Pacific Coast: Existing and New

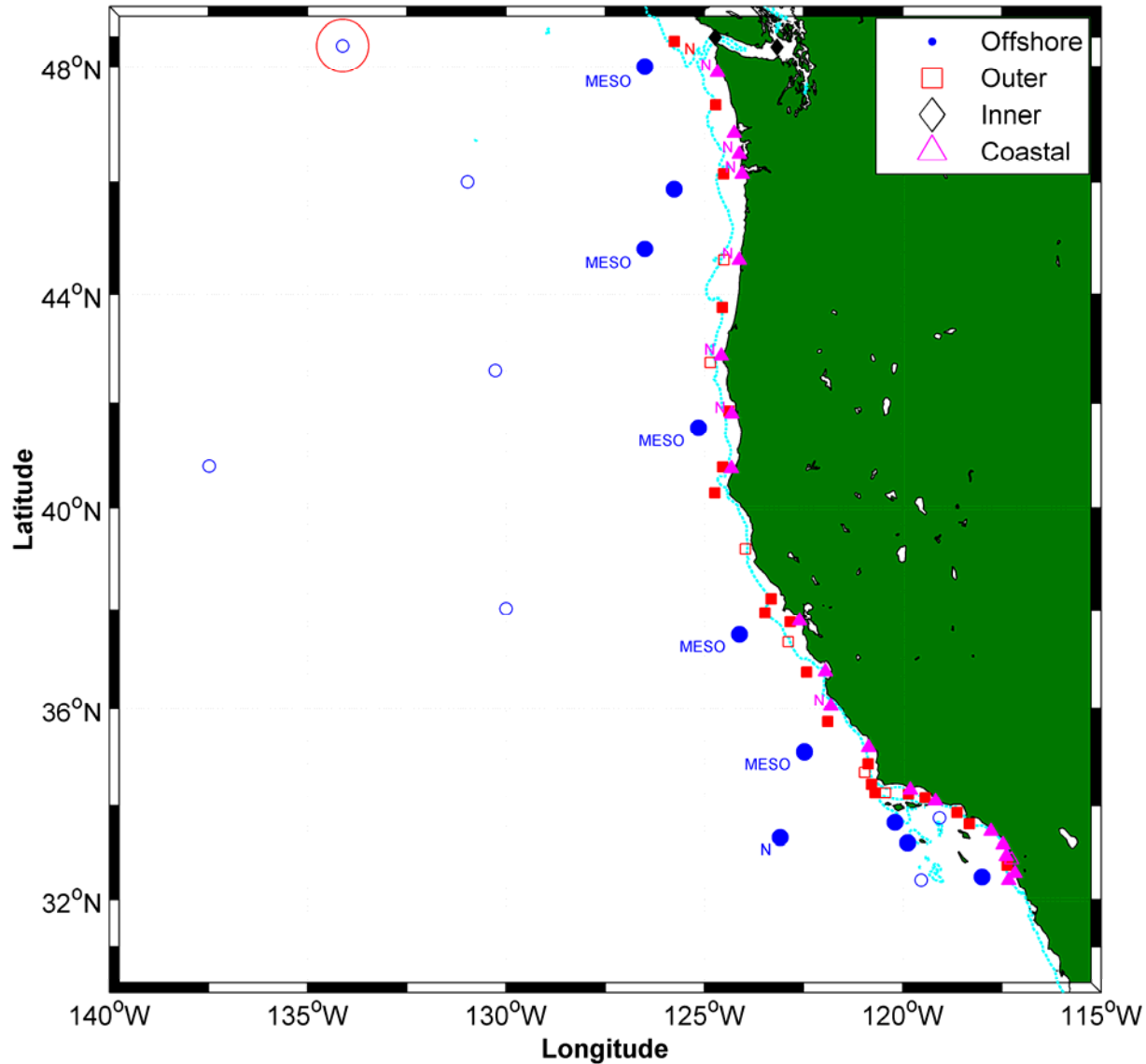


Table of Wave Observation Sites

Total: 102 new, 128 upgrades

Summary of Planned and Existing Wave Measurement Sites																
Region	Offshore Subnet				Outer-Shelf Subnet				Inner-Shelf Subnet				Coastal Subnet			
	Design	Exists	New	Upgrade	Design	Exists	New	Upgrade	Design	Exists	New	Upgrade	Design	Exists	New	Upgrade
Atlantic Coast	14(1)	9(1)	5	9(1)	12	3	9	2	21	15	6	14	42	33	9	25
Gulf of Mexico	6	5	1	5	9	5	4	5	6	1	5	1	24	11	13	11
Pacific Coast	16(1)	10(1)	6	6(1)	26	25	1	6	2	2		2	20	13	7	1
Alaska	6(2)	6(2)		6(2)	10(3)	9(3)	1	9(3)	4	1	3	1	6	6		3
Pacific Islands	6	5	1	3	1	1							9	4	5	1
Great Lakes									12(8)	9(8)	3	9(8)	20		20	
Caribbean	8	8		8									3		3	
Total	56 (4)	43 (4)	13	37 (4)	58 (3)	43 (3)	15	22 (3)	45 (8)	28 (8)	17	27 (8)	124	67	57	42

Note: Number of Canadian sites is given in parentheses; these are not included in the totals

Waves Plan: Summary

- An integrated plan for wave measurement in the US that addresses spatial and temporal coverage, and accuracy requirements of wave information users.
- Designed an In-situ observation network – Four Subnets
 - Expanded NDBC's buoy network
 - Inner-Shelf & Coastal gauges by USACE, NOAA, RA's etc
- We've identified requirements, existing assets, new locations and directional upgrades
- Planned system will be a significant improvement over the existing system
- Integrate wave measurements via NDBC & CDIP data centers
- Technology development & training activities included
 - Recognizes that waves are a difficult parameter to measure correctly
 - There is a critical requirement to measure the performance of existing platforms to see if they meet high order directional wave measurement standards.
 - This is an initial focus since don't want to expand network with untested sensors
- At IOOS Program awaiting final review process





QUESTIONS

