3.3.3 Regional Coastal Ocean Observing Systems

In May 2004 the nascent Regional Associations were asked to prioritize what they considered the top five enhancements to the national backbone system. They noted that this process naturally favors enhancements related to physical variables relative to bio/geo/chemical ones. A similar list of priorities for enhancement of the regional observing systems was also provided.

The table below summarizes the statements made by the Regional Associations regarding enhancements needed for the national backbone. Results can be summarized as follows:

- NDBC type buoys - additional buoys are needed with enhanced capability for biological and chemical sampling. To a lesser extent the same applies to NWLON and CMAN stations.
- Stream gauging - more stream gauges are needed with the capacity to sample bio/chemical parameters.
- Surface current measurements - Surface currents are needed in the coastal waters at the 200 km scale in general.
- Bathymetry, topography and shoreline measurements are needed
- Remote sensing information should be enhanced and made more accessible.
- Integrative models of all kinds are required to produce needed products.

DMAC should be considered an overarching issue that must be funded and adhered to at all phases of the creation of the IOOS.

Region	Data Buoys	NWLON	CMAN	Long Range HF Radar	Stream gauging and sampling	Bathymetry and Topography	Integrative Models	DMAC	Other
Hawaii									
AOOS - Gulf	**X[1]**		**X**	**X**	**X**				**Fisheries and ecosystem info**
AOOS - Bering	**X[1]**		**X**	**X**					**"**
AOOS - Arctic	**X[2]**		**X**		**X**	**X**			**RADARSAT ice coverage, remote sensing ground truth, Navy submarine access**
NANOOS	**X[1]**			**X**		**X**	**X**		**Better access to remote sensing**
CenCOOS	**X**	**X (with more variables)**							**Offshore telemetry, more gliders, etc., ship surveys,**
SCCOOS									**Nearshore issues (pollution), sediment management, Bio sampling, continuous (glider, moorings, etc.) monitoring. Ship traffic monitoring, offshore hazards.**
GCOOS	**X**	**X**	**X**	**X**	**X**		**X**	**X**	
SECOORA									
MARA	**X**			**X**				**X**	**Better access to remote sensing, Fleet renewal**
GOMOOS	**XX**	**X**		**X**	**X**				**Improve NCEP forcast, new coastal satellite**

[1] Enhance with bio/chemical variables

[2] Ice capable with solar radiation sensors

GLOS	**X**[1]	**X**[3]				**X**		**X**	**Interconnected waterway sampling, enhanced remote sensing**
Caribbean									

AOOS - Alaska

Alaska proposes to form three regions: Gulf of Alaska, Bering Sea/Aleutians, and Arctic. They provided priorities for enhancements for each regions and overall priorities.

Region Wide Priorities

1. Throughout Alaska waters, a system to acquire, process, integrate, and present remote sensing products that incorporate scatterometer, sea surface height, sea ice cover, ocean color, wave height and direction, water column currents, water column salinity, and water column temperature data.

2. Data management and communications systems that provide real-time data for use by Alaska stakeholders, including the assimilation of data into models that provide information products such as ocean circulation patterns (taking into account waves, eddies and fronts) and improved nearshore forecasts to minimize impacts of coastal erosion on development; and systems that store the data and metadata from the observing network in formats that provide ready access to researchers, regulators, educators, and public and commercial users.

3. Develop models that assimilate data to simulate circulation, including features such as upwelling, eddies and fronts.

4. Systems to connect marine data and models with terrestrial data, especially given the importance both of fresh water input into the marine system and anadromous fish such as salmon which rely on both freshwater and marine waters.

5. Comprehensive coastal and offshore mapping and charting.

[3] upgrade with bio/chem

6. Shoreside capabilities to develop, stage, deploy, operate, and maintain observing systems to include AUVs, cabled and moored systems, and ground- and air-based remote sensors throughout Alaska.

Gulf of Alaska

- Increase the number of meteorological/oceanographic buoys/moorings to obtain a density of observations comparable to at least *half* that in the rest of the U.S. coast. The Gulf of Alaska coastline is more than twice as long as that of the northern California/Oregon/Washington coast, yet has about half the number of buoys/C-MAN stations. At present, areas in the Gulf of Alaska region that have an extreme paucity of buoys are Southeast and Inland Passage, Cross-Sound to Prince William Sound, Kodiak, and Alaska Peninsula. All oceanographic observations should be expanded to include salinity, oxygen, depth-resolved currents, temperature, chlorophyll, nitrate, biological variables (e.g., plankton density using acoustics), visibility, wave height/direction, and incoming solar radiation.
- Deploy long range High Frequency (HF) radar surface current mappers to the equivalent of *half* the density of the rest of the coastal US.
- Enhance fisheries and ecosystem information collection and products.
- Increase the number of stream gauges, and enhance them to include monitoring water quality and sediment load in real-time, particularly on large rivers.

Bering Sea / Aleutians

- Enhance and sustain the number of monitoring buoys over the Bering Sea shelf, each with the capability to measure meteorological, water property, and biological parameters that provide real-time data. Two additional buoys on the eastern shelf and the enhancement of the two existing buoys to real-time capability would greatly improve the existing coverage. All oceanographic observations should be expanded to include salinity, oxygen, depth-resolved currents, temperature, chlorophyll, nitrate, biological variables (e.g., plankton density using acoustics), visibility, wave height/direction, and incoming solar radiation.
- Install five C-MAN stations along the Bering Sea coastline between Bristol Bay and Bering Strait.
- Deploy several long range HF radar surface current mappers at pulse points (e.g., Bering Strait, Aleutian Straits) in circulations and major fishing grounds.

- Enhance fisheries and ecosystem information collection and presentation by expanding the area covered by surveys and increasing the oceanic parameters collected.

Arctic

- Four C-MAN stations along the Arctic coastline including Bering Strait, Barrow, Prudhoe Bay, and the Mackenzie River.
- Stream flow gauges at key sites.
- Better bathymetry and nearshore topography measurements.
- Moored oceanographic buoys along the Arctic coast with meteorological and water sensors (including sea-level) to provide real-time data.
- Network of ice-tethered buoys with real-time data reporting to measure radiation balance, surface meteorology, ice mass balance, and ocean physical properties in multi-year ice regions for climate and weather observation and forecasting.
- Continuity of RADARSAT or similar year-round monitoring of sea ice conditions, and extension to include ice characteristics and thickness.
- Validation, calibration and ground-truthing for Arctic conditions of national space-based sensors.
- Routine access to Navy's submarine-based Arctic research program, including under-ice observations of water mass, ice and bottom conditions and in particular, under-ice bathymetry and geophysics to address the U.N. Convention on the Law of the Sea Article 76.

NANOOS - Pacific Northwest

1* Buoys: more (double coverage, esp, fill in WA coast, nearshore, offshore, sanctuaries) and better (salinity, oxygen, depth-resolved currents, temperature, chlorophyll, nitrate, other biological variables, PAR, visibility, full frequency/directional wave spectrum, incoming solar radiation, and a standard interface), co-located with radar and fisheries transects, and the ships to maintain them.

2* Long range HF radar installation through WA, including short-range in the Strait of Juan de Fuca, with maintenance for entire PNW array

3* Coastal/Nearshore Bathymetry and shoreline topography (access to existing data e.g. U.S. Army Corps Eng. Surveys, USGS LIDAR data, hyperspectral; and increased frequency and coverage of such collections).

4* Better access to satellite data & products, delivery and distribution

5* Models (circulation, waves, data assimilation, micro and meso-scale atmospheric) and computer infrastructure to run those

6 Enhance fisheries and ecosystem information (surveys, zooplankton, benthic habitat)

7 Increase stream gauges, include water quality and sediment supply, and make real-time

8 Increase number of sea level sites

9 HAB identification

10 Pilots for sensors/technologies that may become backbone

CenCOOS

The following listing includes the top five priorities for enhancing the national backbone for each category: in situ, remote sensing, and Data Management and Communications.

<u>In situ:</u>

- Increase the number of buoys and types of measurements collected by buoys in the coastal domain and explore lower-cost systems
- Provide infrastructure for sufficient bandwidth for remote telemetry of data from coastal buoys, gliders, drifters, and other platforms
- Increase the number of drifters, floats, and gliders continually deployed in the coastal domain
- Maintain and expand coastal monitoring stations, which include temperature, salinity, tidal height, etc.
- Maintain ship surveys for hydrographic and fisheries purposes

Remote sensing:

We expect that the FY 07-11 priorities for remote sensing will be similar to the FY 04-06 expectations above, given the long lead time for satellite development efforts.

- Ensure long term support, with no data gaps, for satellite altimetry, SST, ocean color, and scatterometry, with science data quality validation and long term archival of data
- Support the development of a Special Events Imager capability for coastal oceans, such as targetable, hyperspectral (350 nm - NIR or SWIR) ocean color sensor. This would provide temporal coverage adequate for capturing physical processes such as tidal forcing, and would improve retrievals in cloudy or foggy regions. Spatial resolution should be at least 250 m. Simultaneously, increase the frequency and spatial resolution for ocean color, sea surface temperature, winds, and altimetry, at a minimum
- Provide automated, near real time access to remote sensing products via subscription or an OpENDAP type system. Develop national clearinghouses for wide distribution of datasets such as SAR, which are currently expensive and difficult to acquire.
- Capitalize upon the State of California's investment in High Frequency (HF) radar and associated technologies provide funding through the regional associations for the operation and maintenance of the California Coastal Ocean Currents Monitoring Program, as part of the national HF effort
- Develop remote sensing capability for sea surface salinity

Data Management and Communications:

- Ensure sufficient bandwidth for data communications and computing power for atmospheric and oceanic simulations (modeling)
- Operate and distribute the results from high-resolution atmospheric mesoscale models
- Provide guidance on inter-regional coordination for data management and communications
- Define who on the national level is responsible for handling and providing: a) data in real-time/near-real time; and b) more scientific quality data (QA/QCd)
- Demonstrate enhanced data products using gridded and non-gridded data from the national backbone

SCCOOS

Top six priorities for enhancing the national backbone (in situ and remote sensing, DMAC)

There are several applications we have in mind for southern California that differ from, or have higher priority here than the rest of the country. The six listed below are not prioritized (we are in the process of narrowing these down to a list of only five).

1. Beach water quality and impacts on marine life.

- Moorings in strategically relevant areas (near major runoff sources in Southern California) for measurement of physical, chemical (nutrient), and bio-optical (suspended particulate, chlorophyll, phytoplankton bloom discrimination, satellite ground truth) parameters. Similar moorings that would also include the measurement of temperature, currents, surface waves, and meteorological parameters may also be sighted at other, non-runoff regions such as in areas of special biological significance.
- Modeling that adequately resolves the nearshore region providing high resolution dispersion estimates for contaminants in the nearshore region and providing beach water quality predictions.
- Routine, telemetered measurements of nearshore (<=10 m water depth) current, wave height and direction. The emphasis for these is near known sources of coastal bacteria discharge, and is weighted by public beach usage.
- Building from, and providing operational support to existing observatory elements.
- Nearshore (as opposed to Mississippi river type) watershed management.

2. Beach sand management and erosion.

- Regular monitoring of beach sand volume and morphology through aerial photographs, LIDAR, and acoustic sensing to determine sand transport and sand resources along the coast of CA.
- Operational models of wave driven sand transport.

3. Observations to support Ecosystem Health Assessment and Marine Life Resource Management

- Observations of species: species observations are the basic measurement underlying scientific judgments and products related to resources and ecosystems. Existing surveys do not sample all habitats, nor are all species of concern surveyed; the frequency of observations are often below that needed to track annual trends, and enhancement beyond FY 04 levels are needed.

Improve sampling technology for species. Using off the shelf robotics, acoustical and optical data sampling technology for species abundance in time and space can be collected from habitats not now accessible and on a more rapid and cost-effective basis

- Data assimilation modeling is the optimal tool for placing species observations into an environmental context, which is essential for assessments of ecosystem health, status of resources and effects of climate change. These models have not yet reached a state in which they are practical operational tools for the west coast. Development of these tools needs to be accelerated in order to be ready for use in IOOS products.
    4. Numbers of moored and autonomous instruments for continuous monitoring of physical and bio-optical ocean properties should be increased. Greatly enhanced environmental data from moored or autonomous instruments are central elements in improving the accuracy of data assimilation models. The numbers of autonomous instruments must be increased to provide accurate representations of ocean dynamics.
- Increased spatial and temporal resolution of important runoff areas using autonomous glider fleets. Variables include temperature, salinity, optical signals for suspended particulate material, chlorophyll, and dissolved oxygen. Particularly important areas in Southern California include Tijuana River discharge, San Pedro Bay, Santa Monica Bay, and Santa Clara/Ventura River mouths.

Increase availability of research vessels. A general problem for the entire coast is the lack of vessels to install and maintain sensor arrays, and make species observations; capacities in these areas shall be limited by the availability of suitable vessels.

5. Shipping traffic management (this is everywhere, but heightened here because of the size and national security interests of our ports)
6. Offshore hazards including earthquakes, tsunami, and flood predictions

In contrast, there are several items that seem to have gained national attention, that are of less interest to us, including things like coral reefs, harmful algal blooms, etc.

GCOOS - Gulf of Mexico

1. Efforts to improve DMAC compliance in the Gulf region

• NDBC is working with several Regional Observing Systems and providing a QA/QC and real-time data distribution service using a product called the "MODEM Kit". In the Gulf of Mexico NDBC is working with TABS, COMPS, TCOON, and LUMCON. We will expand this activity to include other data providers so as to achieve complete integration of real-time measurements in the region.

• NDBC also places these data sets on a DODS server once a month. They will expand this to real-time on an OPENDAP server, using a Live Access Server as a user interface to keep current with the DMAC guidance.

• Transition the NDBC Real-Time OPENDAP server to operational status

2. Enhancement of NDBC buoy and C-MAN networks

• Add wave directionality to wave height—useful for rip current forecasting and sediment transport estimation
• Add visibility measurements—needed off Mississippi River and other areas for biological productivity estimation and for river-ocean connection
• Add ADCPs—constraints for models and for HF radar network
• Add ecosystem measurements, as feasible
• Add water level measurements
• Increase the number of stations in these networks by a factor of five, including additional meteorological stations in the near coastal zone for use in forecasting surface currents for HABSOS as well as improved regional models
• Develop a deep-ocean, advanced capability sentinel station. Envisioned is a station with a measurement suite capable of characterizing the environment form the sea floor to the troposphere (-3000 m to +3000 m). It would serve both as a sentinel station in the U.S. EEZ but also as a test bed for advanced technology.

3. Improve and enhance monitoring of inputs to the coastal ocean from the continent

• Monitoring in additional streams
• Monitoring to include nutrients and other ecosystem indicators, as well as flow rates—uses include monitoring coastal eutrophication

4. Establish long-range HF radar monitoring of surface currents

This should be as a part of the national surface current monitoring initiative being planned by Ocean.US.

5. Integration and assessment of numerical circulation models for the region.

One or more numerical circulation models for the Gulf of Mexico should be added to the national backbone. The benefits of having both high density model data (compared to measured data density) and the capability to forecast currents, will greatly increase the usefulness of GCOOS.

• Create a portal to outputs from all accessible full Gulf models
• Ensemble and assess the skill of these models
• Provide boundary conditions for smaller-scale coastal and estuarine models

6. Integrate water level network for Gulf of Mexico

• Adjust all water level measurements to a common datum
• Analyze all extant water level records for regional trends and assess new requirements
• Expand NWLON (NOS National Water Level Network) as needed based on foregoing activities

SERA-COOS - South Atlantic Bight

MARA - Mid-Atlantic Bight

1. National Long-range Multi-static HF Radar network to provide surface current maps through most of the EEZ. This is the only technology capable of providing this high need dataset.

2. Enhancements to the NOAA Data Buoy network which provide mostly surface data. Upgrades include more buoys for better resolution of wind and wave fields (which often vary on the larger synoptic scale of the atmosphere), the ability to place downward looking acoustic sensors (like ADCPs) on the surface moorings, and the ability to put long-range HF Radar transmitters on the larger buoys to enhance resolution and extend coverage.

3. Greater access to a larger number of satellites, including international. Negotiations with foreign governments for licensing fees. Access to more satellites reduces revisit intervals so we can begin to look at the shorter time scales of the coastal ocean. High spectral and spatial resolution further facilitates the production of coastal products. Develop a national archive for the satellite data. Many of these products may be single use by individuals, but there are many users around the country.

4. UNOLS/NOAA fleet renewal, including ships and aircraft. Observatories increase the need for coastal vessels, as does interdisciplinary research and fast response to events. More coastal vessels will be required as well as coastal aircraft. Continue to implement the plan for four national aircraft centers (east, gulf, west coasts and Alaska).

5. Data management at a national level that includes existing national centers at NOAA and NASA that makes it easier to share data.

GLOS - Great Lakes

Open Lake observations including: NOAA-NDBC to upgrade and expand buoy and C-MAN network to provide more meteorological observations and subaqueous chemical and biological sampling; NOAA-GLERL to deploy environmental research buoys in coordination with academic institutions; and, NOAA-NWS to generate overlake precipitation estimates from WSR-88D networks.

Interconnecting waterways observations including: NOAA/USACE multiple permanent acoustic Doppler current profiler (ADCP) installations in each river course; repetitive USACE flow measurements; NOAA/USACE/USGS near real-time operational two-dimensional flow modeling of each river course; expansion of models to address sediment transport and oil/toxic spill dispersion; and, USGS ADCP installations on major tributary inflows to the Great Lakes.

Nearshore observations including: NOAA-NOS upgrades and expansions to water level gauging stations to provide meteorological and subaqueous chemical and biological sampling; NOAA-NGS expansion of geodetic control networks; USACE nearshore wave gauging and high frequency radar current metering; and USACE integrated aerial mapping to provide detailed bathymetric/topographic terrain models and hyperspectral habitat mapping.

Remote Sensing including: NASA/NOAA imagery acquisition for local processing, including imagery from MODIS, AVHRR, SeaWiFS, MERIS, GOES, QuickSCAT, Radarsat, etc; , DHS support to expand NOAA's CoastWatch program to include expedited turnaround of high resolution thermal, hyperspectral and radar imagery for use in emergencies such as oil/toxic spill responses.

Information Integration including: DMAC implementation throughout NOPP agencies to standardize national information infrastructure.

Hawaii

N/A

Caribbean

N/A