7.1

THE NWS MARINE OBSERVATION NETWORK: COASTAL MARINE COMPONENT OF MULTIPLE OBSERVING SYTEMS

Don T. Conlee* and Paul F. Moersdorf

NOAA's National Data Buoy Center
Stennis Space Center, MS 39529

1. INTRODUCTION

The National Weather Service's (NWS) National Data Buoy Center (NDBC) operates the Marine Observation Network (MON). This network consists primarily of moored buoys and shore and platform-based coastal marine stations around the continental U.S., Alaska, Hawaii, and the Great Lakes. NDBC also operates the Deep-ocean Assessment and Reporting of Tsunamis (DART) buoy network in the Eastern Pacific Ocean. A phased transition of the Tropical Atmosphere Ocean (TAO) array is underway from the Pacific Marine Environmental Laboratory (PMEL) to NDBC.

2. MON DESCRIPTION

The first operational buoy of the MON was station 46001in the Gulf of Alaska, a 12 meter discus buoy deployed in 1972 and maintained by a string of successive buoys since. The MON has grown steadily in both buoy types and numbers to a count of 88 buoys and 56 Coastal Marine Automated Network (CMAN) stations in 2004. Figure 1 is a depiction of the present network.

The NDBC-developed 3m discus buoy is the staple of most coastal locations. The 6m NOMAD buoy of Navy 1950's heritage is used farther offshore and in harsher environments. The large 10 and 12m buoys, which must be towed to station location, are typically used in extremely remote and harsh areas where servicing intervals may be up to 4 years. These buoys contain complete redundant instrumentation for survivability. Figure 2 shows the 3 major types of buoys employed in the MON today.

CMAN stations are located at coastal locations such as lighthouses, piers and offshore navigation platforms. These stations collect the same meteorological parameters as MON buoys and oceanographic parameters as proximity to water will allow. Figure 3 shows typical CMAN station installations.

The set of parameters which can be collected by the MON is shown in Table 1. The traditional MON operational customer (e.g. NWS forecast offices and centers, mariners) typically favors real-time reliability with reasonable accuracy over high-precision measurement. However, in most parameter cases, the NDBC system can deliver science-grade accuracy for non-real time purposes such as climate study.

3. MON AND THE IOOS

The Integrated Ocean Observing System (IOOS) is the U.S. contribution to the Global Ocean Observing System (GOOS) and the Global Earth Observing System of Systems (GEOSS). Because the IOOS is primarily associated with U.S. and territory coastal oceans, it is sometimes used synonymously with the Coastal Component of the GOOS (C-GOOS).

Corresponding Author Address: Don Conlee, Chief Scientist, National Data Buoy Center, 1100 Balch Blvd., Stennis Space Center, MS 39529 don.conlee@noaa.gov

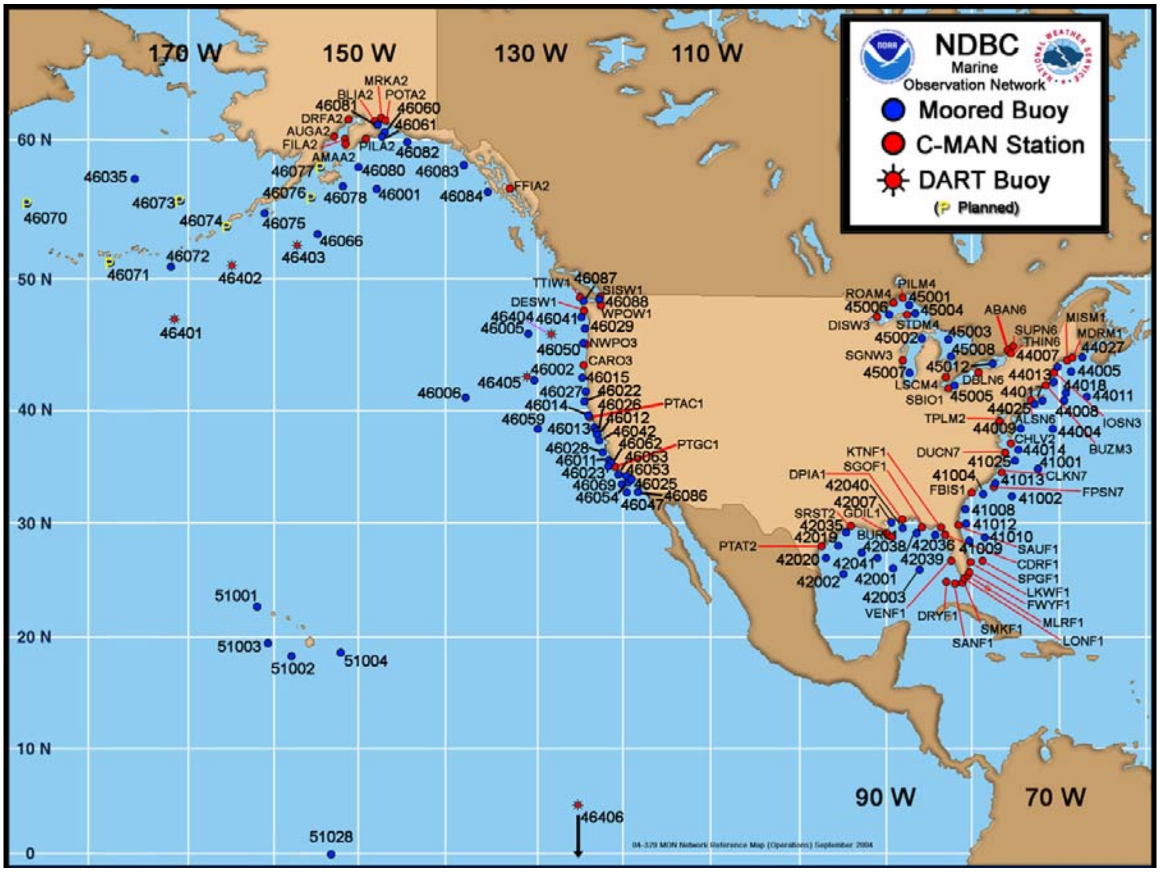

FIG 1. Map showing locations of NDBC MON stations as of November, 2004.

FIG 2. L to R: 3m and 10m Discus Buoys, 6m NOMAD buoy.

FIG 3. Typical CMAN station configurations.

The NDBC MON constitutes the largest offshore component of the federal contribution to the IOOS, which is known as the "federal backbone." The federal backbone is critical to bringing a *sustained* ocean observing capability to the IOOS. Joining and expanding upon the backbone are Regional Coastal Ocean Observing Systems (RCOOS) which are administered by Regional Associations (RAs). These systems today are typically academic or laboratory-run observing systems with a focus on research and development.

NDBC has established an IOOS Real Time Data Assembly Center (DAC) to facilitate the inclusion of RCOOS data in real-time operational activities. Using a program known as the Meteorological and Oceanographic Data Exchange Module (MODEM), NDBC now collects data from more than 12 RCOOS organizations/ institutions. These data undergo standard NDBC automated and human quality control processes, and are inserted in real-time into the Global Telecommunications System (GTS). By passing data through NDBC, additional services include display on the highly-utilized NDBC web site (http://www.ndbc.noaa.gov), telephone query by the Dial-A-Buoy system, and provision of data to the designated archive agencies (National Oceanographic Data Center and National Climatic Data Center). Figure 4 depicts the flow of data from RCOOS provider to end-user. At the end of 2004, the amount of non-NDBC observations was approaching 40% of the total NDBC DAC-distributed observations (Figure 5). Gilhousen (2002) describes the MODEM process in more detail.

The Airlie House Report (Ocean.US, 2002) called for expansion of the number of NDBC buoys to 500 and enhanced ocean parameter representation. Subsequent documents have called for a total number of 350. Although the number of NDBC buoys has grown through small expansions, the first major impact of this recommendation is the anticipated FY05-09 program to enhance approximately 20 stations per year with current profiles and salinity observations. Additional enhancements to the NDBC DAC will also be performed to enable the processing of the rapidly expanding RCOOS data. Beginning in FY06, expansion of directional wave sensing to a core (vice sponsored) capability is anticipated. The significant expansion of the MON (and the federal backbone) in number of buoys remains an effort for future IOOS planning.

4. RELATIONSHIP TO ISOS/IUOS

The NOAA backbone contribution to the IOOS joins the Integrated Surface Observing System (ISOS) and the Integrated Upper-Air Observing System (IUOS) as a 3-component NOAA Integrated Observing System. Although not explicitly included in the ISOS, the NDBC MON joins other NOAA coastal observations such as the National Water Level Network (NWLON) in defining the coastal margins of ISOS. NDBC and the National Ocean Service (NOS) Center for Operational Oceanographic Products and Services (CO-OPS), have begun a cooperative project to share, improve and standardize our respective real-time data.

Upper Air observations in the coastal oceans are rare, but would be extremely

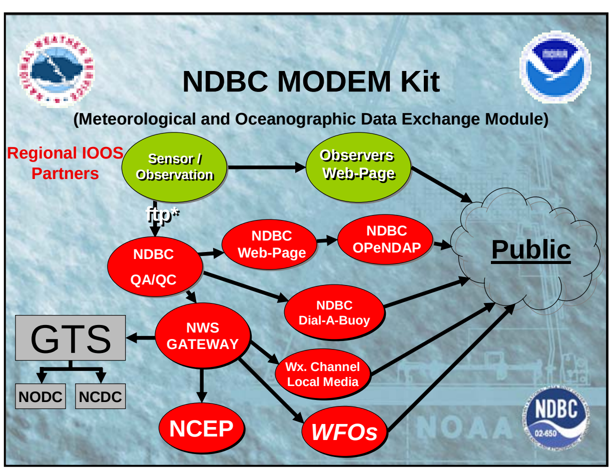

FIG 4. Data flow from IOOS partner to customer.

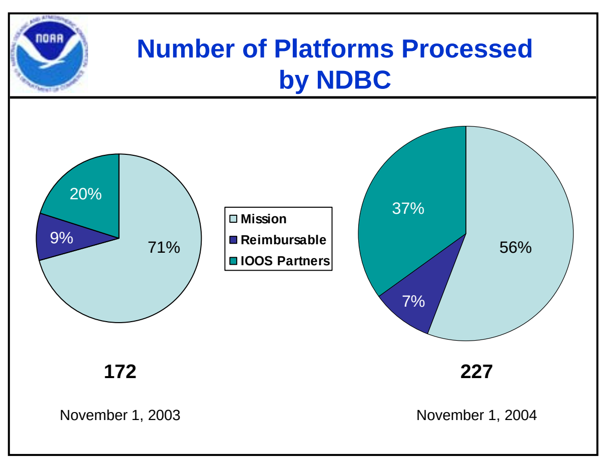

FIG 5. One year growth of stations processed by NDBC. Mission is base-funded, Reimbursable is deployed by NDBC for a funding sponsor.

Parameter	Reporting Range	Reporting Resolution	Sample Interval	Sample Period	Real-Time System Accuracy	Achievable Accuracy
Wind Speed	0 to 62 m/s	0.1 m/s	1 s	8 min[1]	±1 m/s or 10%	± 0.2 m/s
Wind Direction	0 to 360°	1°	1 s	8 min[1]	±10°	± 5°
Peak Wind	0 to 82 m/s	0.1 m/s	1 s	5 s	±1 m/s or 10%	± 0.2 m/s
Air Temperature	-40 to 50 °C	0.1 °C	90 s	8 min	±1 °C	± 0.09 °C
Atmospheric Pressure	800 to 1100 hPa	.1 hPa	4 s	8 min	±1 hPa	± 0.07 hPa
Sea Surface Temperature	-7 to 41 °C	0.1 °C	1 s	8 min	±1 °C	± 0.08 °C
Conductivity[2] (Salinity)	0 to 70 µS/cm	0.0001 µS/cm	1 s	8 min	±0.001 µS/cm	±0.001 µS/cm
Significant Wave Height	0 to 35 m	0.1 m	0.39 s	20 min	±0.2m or 5%	±0.2m or 5%
Wave Period	3 to 30 s	0.1 s	0.39 s	20 min	±1 s	±1 s
Nondirectional Wave Spectra	0.03 to 0.40 Hz	0.01 Hz	0.39 s	20 min		
Directional Waves[2]	0 to 360°	1°	.5 s	20 min[3]	±5°	±5°
Dew Point Temperature[2]	-35 to 30 °C	0.1 °C	1 s	8 min	±1 °C	± 0.31 °C
Shortwave Radiation[2]	0 to 2800 W/m^2	1 W/m^2	0.5 s	60 min	±5%	±1%
Precipitation Rate[2]	1 to 1600 mm/hr	1 mm	1 s	15 min	±5%	±5%
Ocean Currents (ACDP)[2]	0 to 100 cm/s	0.5 cm/s	1.5 s	20 min	±2 cm/s	±2 cm/s
Sea Level[4]	0 to 99.99 ft	0.01 ft	1 s	3 min	±0.1 ft	±0.1 ft
Water Column Height (regular)[5]	0 to 6.8 *10^6 mm	1 mm	1 s	15 min	±1 mm	±1 mm
Water Column Height (event)[5]	30 to 6.8 *10^6 mm	1 mm	1 s	15 sec	±1 mm	±1 mm

[1]For continuous winds, succesive 10-min samples
[2]Parameter reported on selected buoys
[3]Wave sampling period 40 min on some systems
[4]Parameter reported on selected stations
[5]Parameter reported on tsunami buoys

TABLE 1. MON Parameters and characteristics.

valuable to weather analysis and numerical forecasting. NDBC is exploring the feasibility of upper air observation via passive radiometric means on moored platforms. It may well be that in the future, the MON has a role in the IUOS.

5. CLIMATE OBSERVATIONS

The typical MON station contains proven instrumentation, much of which is identical to that of climate monitoring networks such as the TAO array and the Wood's Hole Ocean Reference Station. Taking into account the relatively long time series at many locations, the MON is already an important part of the NOAA Office of Climate Observation's (OCO) U.S. contribution to the Global Climate Observing System. NDBC is prototyping a Climate Reference Buoy, which will combine standard observations with post-calibration and new or increased parameters of climate interest. The Implementation Strategy for U.S. Ocean Carbon Research (Doney, 2004) highlights the need for carbon dioxide measurements in the North American coastal zones, where even the sign of the CO2 flux is not well known.

Eventual implementation of the Climate Reference Buoy program will complement the land-based Climate Reference Network (CRN) and provide approximately 20 moorings serving dual purposes as MON real-time stations and climate sentinels.

6. TSUNAMI NETWORK

In 2003, PMEL transitioned the DART network of six buoys to NDBC. This subset of the MON is a major component of the U.S. National Tsunami Hazard Mitigation Program (NTHMP). DART buoys detect the passage of a tsunami via bottom pressure sensors and appropriate filtering. Plans are underway to expand this network with two additional moorings.

NDBC is investigating the feasibility of additional observations on these platforms, including a precision Sea Surface Height (SSH) capability for altimetry calibration /validation, operational oceanography and sea level monitoring purposes.

7. SUMMARY

Through a concerted effort to engage with emerging observation programs and individual observing systems, NDBC and our partners are substantially achieving the integration sought by programs such as IOOS. However, this is primarily an integration of existing capability. The expansive vision of GOOS, IOOS, GEOSS, GCOS, etc. and of recent reports such as the U.S. Commission on Ocean Policy (2004) to grow and sustain observation capability remains a significant challenge.

8. REFERENCES

Doney, S.C., 2004: Ocean Carbon and Climate Change (OCCC): An Implementation Strategy for U.S. Ocean Carbon Research, Carbon Cycle Science Ocean Interim Implementation Group.

Gilhousen, D.B., 2002: How to Distribute Real-Time Marine Observations, *Oceans 2002 MTS/IEEE Conference Proceedings*, Biloxi, MS., 742-743.

Ocean.US, 2002: Building Consensus: Toward an Integrated and Sustained Ocean Observing System (IOOS). Ocean.US, Arlington, VA. 175pp.

U.S. Commission on Ocean Policy, 2004: An Ocean Blueprint for the 21st Century, Final Report of the U.S. Commission on Ocean Policy - Pre-publication Copy, Washington, D.C. ISBN#0-9759462-0-X.