Began as pilot project (2007-2010)
- First spiral of IOOS data management development
- Evaluate in FY 2010

Limited scope for reduced risk
- 3 data providers and 4 customers
- 7 core variables
  - Currents, Temperature, Salinity, Water Level, Winds, Waves, Ocean Color (chlorophyll)

See http://ioos.gov/dif/ for:
- Links to data access services
- SOS schema and software
- Systems engineering documents

(Data Integration Framework (DIF) (Graphic by i3 Aerospace Technologies Pty Ltd – used with permission))
IOOS DIF Project Data Providers

**National Weather Service (NWS)**
National Data Buoy Center (NDBC)

- 172 NWS Buoys
- 228 IOOS Regional observations
- 55 Tropical Atmosphere Ocean (TAO) Buoys
- 47 Deep-Ocean Assessment and Reporting of Tsunamis (DART)
- Surface Currents from High-Frequency Radar (HFR)

**National Ocean Service (NOS)**
Center for Operational Oceanographic Products and Services (CO-OPS)

- National Water Level Observation Network (NWLOM)
- Physical Oceanographic Real-Time System (PORTS)

**National Environmental Satellite, Data, and Information Service (NESDIS)**
CoastWatch

- Satellite Ocean Color (Aqua MODIS)
## Recommended Web Services and Data Encodings

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Web Service</th>
<th>Encoding</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-situ data (buoys, piers, towed sensors)</td>
<td>OGC Sensor Observation Service (SOS)</td>
<td>XML based on OGC Observations and Measurements (O&amp;M)</td>
</tr>
<tr>
<td>Gridded data (model outputs, satellite)</td>
<td>OpenDAP and/or OGC Web Coverage Service (WCS)</td>
<td>NetCDF using Climate and Forecast (CF) conventions</td>
</tr>
<tr>
<td>Images of data</td>
<td>OGC Web Map Service (WMS)</td>
<td>GeoTIFF, PNG etc. -possibly with standardized styles</td>
</tr>
</tbody>
</table>

[OGC = Open Geospatial Consortium]
Summary

- Standardized data access services implemented at operational data providers
  - SOS: Point, Profile, Time Series, Collections
  - OpenDAP/WCS: Regular Grids

- Implementing detailed metadata for sensors, platforms, systems

- SOS, WMS, WCS submitted as IOOS standards
  - Need to document SOS Profile for ocean observations

- In planning: Expansion of DIF towards IOOS
  - Service types (Registry, Catalog, …)
  - Data types (trajectory, unstructured grid, imagery)
  - Data providers, data customers

See http://ioos.gov/dif/
Backup Slides
SOS for *in situ* Observations

**Sensor Systems**

- Observations
- Data Provider
- SOS (Sensor Observation Service)
- Data Values
- Procedure Metadata
- Table of Contents
- Capabilities XML
- Obs. & Meas. (O&M) XML
- SensorML

**Metadata**
- Quality Control
- Metadata
XML
Extensible Markup Language
Generic method for structuring text data

specialized
by

OGC GML
Geography Markup Language
XML that can represent any geospatial feature

specialized
by

OGC O&M
Observations and Measurements Model
GML that describes the act of measuring real-world phenomena and the result of the measurement
IOOS Data Model for Time Series at a Collection of Points

• **Collection**
  - **Station 1**
    - **Time 1**
      - quantity 1
      - quantity 2
    - **Time 2**
      - quantity 1
      - quantity 2
  - **Station 2**
    - **Time 1**
      - quantity 1
      - quantity 2
    - **Time 2**
      - quantity 1
      - quantity 2
IOOS Metadata Linkage Model
(Sensors, Stations, Networks, Datasets and Services)
SOS Profile/Best Practices

- SOS and O&M specs are fairly general
  - Need community specialization/restriction
- IOOS adopting, defining or researching practices:
  - O&M schema
  - KML+JSON (Javascript Object Notation)
  - URIs for sensors, stations, networks, CRS, phenomenon names
  - HTTP GET request encoding
  - SensorML metadata
  - Observation Offerings
IOOS Practice: Observation Offerings

• Each station (buoy, fixed sensor package) is a separate Offering from the SOS
  – Allows requests for data from 1 station at a time

• Multi-station Offerings:
  – “All stations” Offering
    • User specifies bounding box instead of station ID
  – Soon: program-specific or event-specific Offerings
    • E.g., “all Hurricane Katrina data”
  – Maybe: phenomenon-specific Offerings
    • E.g., “all temperature data”

• Offering includes ID and English name
  – gml:name = ID
  – gml:description = name

• May replace multiple sensor IDs per offering with single station ID
IOOS Practice: Identifiers

- Using URNs for IDs of sensors, stations, networks (*URN = Uniform Resource Name*)
- Following “OGC Definition URN” practice
- Examples:
  - urn:x-noaa:def:network:noaa.nws.ndbc::all
  - urn:x-noaa:def:station:noaa.nws.ndbc::21418
  - urn:x-noaa:def:sensor:noaa.nws.ndbc::21418:tsunameter0
- Also using URNs for EPGS CRS identifiers
- Using URLs for phenomenon names
  - Adopting MMI/CF URLs:
    - http://mmisw.org/ont/cf/parameter/sea_water_temperature
  - Allow trailing component as abbreviation
    (sea_water_temperature)
IOOS Practice: GetObservation Request

• Supporting both HTTP POST requests and HTTP GET
  – HTTP POST defined in spec, GET left out
  – Mostly following Oceans IE Best Practice for GET
    • For Bounding Box, using FOI that could be a BBOX or (in future) a named FOI:
      featureofinterest=BBOX:minlon,minlat,maxlon,maxlat
WCS and/or OpenDAP for Gridded Data and Model Outputs

Table of Contents
- Metadata
- Data Values
- Data Provider
- Quality Control
- OpenDAP
- WCS (Web Coverage Service)
- Table of Contents
- Data Values
- Metadata
Federated, Service-Oriented Architecture

- **IOOS Portal**
  - Web Interface
    - Registry
    - Catalog

- **Regional Portal**
  - Registry
  - Catalog

- **Thematic Portal**
  - Registry
  - Catalog

- **Utility Service**

- **Obs Syst. or Model**
  - Data Center
    - Data access service

- **IOOS Portal**
  - Data Center
    - Data access service

- **Regional Portal**
  - Data Center
    - Data access service

- **Thematic Portal**
  - Data Center
    - Data access service

- **Utility Service**
  - Data Center
    - Data access service
IOOS Architectural Layers
and Relationship to IOOS “Subsystems” and ISO Model

IOOS “Subsystems”

ISO 3-Layer Model
(International Organization for Standardization)

Observing Systems

Modeling & Analysis

Client Components

Utility Services

Data Access Services

Data Providers

Data Management and Communications (DMAC)

User Interface Tier

Business Process Tier

Data Access Tier

Observing Systems

20
Component Types Needed for IOOS
Computational Viewpoint from Reference Model for Open Distributed Processing (RM-ODP)

Legend:
- Working examples
- Starting/partial
- Not yet addressed
IOOS Data and Metadata Types

Information Viewpoint from Reference Model for Open Distributed Processing (RM-ODP)

<table>
<thead>
<tr>
<th>Category</th>
<th>Types</th>
</tr>
</thead>
<tbody>
<tr>
<td>Service Metadata</td>
<td>(OWS Capabilities XML, ISO 19119)</td>
</tr>
<tr>
<td>Discovery Metadata</td>
<td>(FGDC, ISO 19115/19139)</td>
</tr>
<tr>
<td>Controlled Vocabularies</td>
<td>(CF, MMI, OGC, GCMD, URNs)</td>
</tr>
<tr>
<td>QA/QC Metadata</td>
<td>(QARTODS/Q20)</td>
</tr>
<tr>
<td>Sensor/Platform Metadata</td>
<td>(SensorML)</td>
</tr>
<tr>
<td>Data Encoding Conventions</td>
<td>(GML, KML, O&amp;M, SWEC, CSML, NetCDF/CF)</td>
</tr>
<tr>
<td>Collection Types</td>
<td>(Time Series, Multi-Station Obs)</td>
</tr>
<tr>
<td>Sampling Feature Types</td>
<td>(Point, Profile, Trajectory, Reg Grid, Unstructured Grid)</td>
</tr>
<tr>
<td>Ocean Properties</td>
<td>(Temperature, Salinity, Currents, Waves, Chlorophyll,</td>
</tr>
</tbody>
</table>
IOOS DIF Customer Projects

Coastal Inundation: Sea, Lake and Overland Surge from Hurricanes (SLOSH) model

Hurricane Intensity: Real-Time Ocean Forecast System (RTOFS-Atlantic)

Harmful Algal Blooms: HAB Forecast System (HAB-FS)

HAB Intensification Potential

low

high

Integrated Ecosystem Assessments: Environmental Research Division Data Access Protocol (ERDDAP) application
Additional IOOS DIF Customers (in progress)

Google: Standardized access to observations for Google Oceans
- Exploring KML+JSON

Tsunami scientists: Prepackaged collections of event-specific observations from DART buoys

Travel time map for November 29, 1975 tsunami in Hawaii (NOAA NGDC).