Arc Marine – Managing and Analyzing Ocean and Coastal Data in ArcGIS

Dawn Wright - Oregon State University
Katsura Iizuka - ESRI
Topics

- Overview of the Arc Marine data model
  - Common marine data types
  - Feature & object classes; initial case studies
- Introduction to the Arc Marine tutorial
- Arc Marine with other data models
- Discussion of tools, initiatives
- Open for questions

Ranks among top models (Hydro, Water Utilities, GIS for the Nation, etc...) in terms of most downloads (more than 8200 times as of June 2009).
Overview of the Arc Marine Data Model
Arc Marine Purpose

• Your Geodatabase Template
  – Data collection at sea/shore ... to final geoprocessing, analysis
    • Control of required data fields, common data structure
  – Simplify enterprise GIS project implementation
    • e.g., cruises, MPA networks, habitat mapping

• Program Coding/Application Development
  – Common/shared tool development
  – Rapid prototyping
  – Linkage to processing models

• Data Sharing/Networking

• “Schooling” in the Gdb
  – Arc Marine Tutorial in Advanced GIS courses
Arc Marine: GIS for a Blue Planet
ESRI Press, 2007

- By Dawn Wright, Michael Blongewicz, Pat Halpin, Joe Breman
  - Foreword by Jane Lubchenco, now NOAA Administrator
- Full background documentation with 13 case studies

- Ch 1 - Introduction
- Ch 2 - Common Marine Data Types
- Ch 3 - Marine Surveys
- Ch 4 - Marine Animal Data Applications
- Ch 5 - Implementing Time Series & Measurements
- Ch 6 - Nearshore and Coastal/Shoreline Analysis
- Ch 7 - Model Meshes
- Ch 8 - Multidimensional GIS
- Ch 9 - Epilogue

Accompanying Web Site:
Arc Marine Poster, Tutorial, UML/XMI, Tool Suite, other goodies
http://dusk.geo.orst.edu/djl/arCGIS
Arc Marine Design Strategy

“Generic” Marine Data Model

User Group Data Model

Marine Animal User Group

Benthic Habitat User Group

Project Data Model

Marine Animal Project Data Model

Benthic Hab Project Data Model

Inheritance

Image modified from original by P. Halpin, Duke
### Thematic Content ("Layer Stack")

#### Thematic groupings of oceanographic data sets

<table>
<thead>
<tr>
<th>Layer</th>
<th>Map Type</th>
<th>Data Source</th>
<th>Representation</th>
<th>Spatial Relationships</th>
<th>Symbology and Annotation</th>
<th>Data Use</th>
<th>Spatial Data and Accuracy</th>
<th>Location Series Observations</th>
</tr>
</thead>
</table>
| Location Series Observations | Tracking a series of recorded instances of a given animal with varying time intervals
Telemetry recorders and transmitters, animal/bird sightings, ship mounted ADCP | Multipoint features, often with line symbols to establish animal track
Multipoints can have varying depths associated to multiple locations, grouped into a series |
Typical map scales range from 1:10,000 to 1:24,000; locational accuracy –10-50 m |
Point and line symbology annotated with animal/bird type |
Arc Marine Thematic Layers

- **Layer**: Shoreslines
  - **Map Use**: Interface between land and water, shoreline change analyses for erosion/accretion, hazards, planning
  - **Data Source**: Derived from coastal survey maps, nautical charts, aerial photos, LIDAR
  - **Representation**: Linear features
  - **Spatial Relationships**: Can be animated modeled based on map units to represent tidal variance
  - **Map Scale and Accuracy**: Typical map scales range from 1:5000 to 1:20,000; locational accuracy typically 10 m
  - **Symbology and Annotation**: Line symbology drawn with varying weights annotated with VDatum; national cartographic standards often used

- **Layer**: Tracks and Cruises
  - **Map Use**: Shiptracks during a cruise, tracks of vehicles towed from a ship or deployed from a ship underway, autonomous
  - **Data Source**: Shipboard or vehicle GPS log storing time, date, and position
  - **Representation**: Linear features
  - **Spatial Relationships**: Tracks have a direction with time stamps along route, particularly keep sampling stations
  - **Map Scale and Accuracy**: Typical map scales range from 1:24,000 to 1:50,000; locational accuracy ~16 m
  - **Symbology and Annotation**: Line symbology drawn with varying weights and patterns, annotated with date/time and ship/vehicle

- **Layer**: Time Duration Features
  - **Map Use**: Fisheries or algal bloom tracks, marine protected area boundaries, habitat, drifters, oil spills
  - **Data Source**: Derived from nautical charts, legal definitions, driftnets/aquaculture, various measuring devices
  - **Representation**: Linear and polygonal features
  - **Spatial Relationships**: Size, shape, area, and direction change over time may be animated
  - **Map Scale and Accuracy**: Typical map scale is 1:24,000; locational accuracy ~10 m
  - **Symbology and Annotation**: Line and polygon symbology with varying weights, patterns and fills

- **Layer**: TimeSeries Locations
  - **Map Use**: Variations in time of variables measured at fixed observations stations at sea and onshore
  - **Data Source**: Fixed or mobile measuring devices such as hydrophones, acoustic doppler current profilers (ADCP), ocean bottom seismometers (OBS), tide gauges
  - **Representation**: Point features
  - **Spatial Relationships**: Points can be related to center of a grid cell or associated to a time series calculation or numerical model
  - **Map Scale and Accuracy**: Typical map scales range from 1:10,000 to 1:24,000; locational accuracy ~10 m
  - **Symbology and Annotation**: Point marker symbology with associated instrument attributes

- **Layer**: Instantaneous Measured Points
  - **Map Use**: Variations in space of variables measured at a given moment in time through the water column
  - **Data Source**: Instrument casts such as conductivity-temperature-depth (CTD), expendable bathythermograph (XBT), sound velocity profile (SVP), fish density, etc.
  - **Representation**: Point features, vertical profiles
  - **Spatial Relationships**: Points can have varying depths associated to a single location, as well as multiple measurements
  - **Map Scale and Accuracy**: Typical map scales range from 1:10,000 to 1:24,000; locational accuracy ~16-50 m
  - **Symbology and Annotation**: Point marker and linear symbology annotated with associated instrument attributes

- **Layer**: Location Series Observations
  - **Map Use**: Tracking a series of recorded instances of a given animal with varying time intervals
  - **Data Source**: Telemetry, records, and transmitters, animal-held sightings, ship-mounted ADCP
  - **Representation**: Multipoint features, often with line symbols to establish animal track
  - **Spatial Relationships**: Multiple points can have varying depths associated to multiple locations, grouped into a series based upon ID
  - **Map Scale and Accuracy**: Typical map scales range from 1:10,000 to 1:24,000; locational accuracy ~16-50 m
  - **Symbology and Annotation**: Point and line symbology annotated with animal/bird type
<table>
<thead>
<tr>
<th>Layer</th>
<th>Map Use</th>
<th>Data Source</th>
<th>Representation</th>
<th>Spatial Relationships</th>
<th>Map Scale and Accuracy</th>
<th>Symbology and Annotation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Survey Transsects</td>
<td>Geomorphic, sediment transport,</td>
<td>Derived from bathymetry, scientific mesh, one-dimensional hydrological</td>
<td>Interpolated, linear profile view of a surface or subsurface</td>
<td>Cross-sections perpendicular to shoreline or flowlines at varying azimuths to align</td>
<td>1:24,000 locational accuracy ~10 m</td>
<td>Line symbology for surface, often for subsurface tone contrast and balance of grayscale according to data values</td>
</tr>
<tr>
<td></td>
<td>or hydrodynamic analyses along</td>
<td>models; measured by sub-bottom profilers</td>
<td></td>
<td>with surface or control point</td>
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<tr>
<td></td>
<td>profiles or cross-sections;</td>
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<td></td>
<td>subsurface profiling</td>
<td></td>
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</tr>
<tr>
<td>Scientific Mesh</td>
<td>Mapping output of finite element</td>
<td>Above models and satellite data sets</td>
<td>Regularly or irregular spaced point features, scalar: raster TIN model</td>
<td>Attribute values can be used to create interpolated surfaces</td>
<td></td>
<td>Raster surface or TIN can be used to show bathymetry; may be animated</td>
</tr>
<tr>
<td></td>
<td>models, hydrodynamic and</td>
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<td>temperatures</td>
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<tr>
<td>Mesh Volumes</td>
<td>Pelagic or open water</td>
<td>Derived features from scientific meshes, point data from stationary, fixed,</td>
<td>Extended cube or hexagonal pillars stacked to represent volumetric areas</td>
<td>Map scale varies and locational accuracy can range from 1 m to 1 km depending on data</td>
<td></td>
<td>Raster surface with varying depth and backscatter intensity</td>
</tr>
<tr>
<td></td>
<td>environment</td>
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<tr>
<td>Bathymetry and</td>
<td>Terrain analysis, benthic</td>
<td>Raster with depth or backscatter intensity, TIN surface model</td>
<td>Coincident with point from which it was derived, or interpolated; if raster,</td>
<td>Map scale varies and locational accuracy depends on data type and resulting volume</td>
<td></td>
<td>Graduated colors; may be overlain with contours</td>
</tr>
<tr>
<td>Backscatter</td>
<td>habitat classification,</td>
<td></td>
<td>each cell has a depth, if TIN each face joins to form surface</td>
<td>calculation</td>
<td></td>
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<td></td>
<td>morpho-tectonic interpretation,</td>
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<td></td>
<td>cartographic background</td>
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<td>Interpolation of irregularity,</td>
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<td>or regularly spaced single or</td>
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<td></td>
<td>multibeam soundings, LiDAR</td>
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</tr>
</tbody>
</table>

*The Thematic Layers*
Arc Marine UML... Chapters 3-6

Marine Points
- MarinePoint
  - MeasurementPoint
  - FeaturePoint
  - LocationSeriesPoint
  - TimeSeriesPoint
  - InstantaneousPoint

Marine Lines
- MarineLine
  - DataLine
    - GeomteryType: esriGeometryPolyline, HasZ: True, HasM: True
  - TimeQuestionLine
    - GeomteryType: esriGeometryPolyline, HasZ: True, HasM: True
  - SurveyID: esriFieldTypeString
  - Date: esriFieldTypeDate
  - Time: esriFieldTypeTime

Marine Areas
- MarineArea
  - FeatureArea
    - BoundaryType: esriGeometryPolygon
  - TimeDurationArea
    - BoundaryType: esriGeometryPolygon

Tables
- MarineObjects: SurveyInfo
- MarineObjects: MeasuringDevice
- MarineObjects: Vehicle
- MarineEvents
- MarineEvents: ObservationInfo
- MarineEvents: Observation
- MarineEvents: Observation
- MarineEvents: Cruise

MarineEvents can be associated to any MarineLine feature. No relationship class is necessary for building this association.
ObservationInfo can be related to all types of TimeDurationLines via MarineID
Cruise can be related to all MarineFeatures via CruiseID
Using a Design Template

Schema Wizard reads repository or template to create a geodatabase

**Schema Wizard**

Connect to the Repository database.

Repositories are stored in DBMS databases (Microsoft Access or SQL Server).

Please provide the Repository:

- Model stored in XMI file.
- Model stored in Repository database.

Database Path or Connection String:

```
|:\Disciplines\Geology\Draft\Model\repo912.mdb
```

User Name: 

Password: 

< Back  Next >  Cancel
Project Design Methodology

Create Design

- Geodatabase Extract Tool
- Template Model with Schema Wizard
- Reuse Existing Designs and/or Create Tables/Feature Classes

Refine Design

- Template Design
- Import and export XML Schema 0.0

Manage Using ArcCatalog

- Geodatabase
- Load Data

Data Dictionary Report

- Planned Class
- Shape_Length
- Recorded Length
- Road Number
- OBJECT_ID_1
- ROAD_NAME
- Enabling Field Name
- Description
- Subtype Field
- Default Value
- Domain
Marine Surveys (Ch. 3 in Arc Marine Book)
e.g., Instantaneous Points, Time Duration Line, Survey & Cruise object tables

Cape Cod Marine Geological Survey
Brian Andrews, USGS-Woods Hole, MA

Louisiana Subsidence
Warming, sea level rise

MetoScience, FL
Marine Animal Tracking (Ch. 4 in Arc Marine Book)
e.g., Location Series Points, Time Duration Lines and Areas, object tables
and rasters

Ocean Biogeographic Information System,
Pat Halpin et al., Duke U.

Sea Turtle Tracks (*Caretta caretta*)

Sea Surface Temperature (warm core rings)

Source: http://obis.env.duke.edu/datasets/ (Read & McClellan2004)

Source: http://www.po.gso.uri.edu/SST/
“90% of Ireland is undeveloped, undiscovered, and ... underwater.”
Overview of Arc Marine Tutorial
Tutorial Purpose

• Assist in simple data entry into Arc Marine
  – Starting point for project work or specific database design
  – Do-it-yourself exercise in geodatabase building
  – Personalize Arc Marine to fit your needs

• Support for case studies

• Classroom laboratory exercise or workshop module
Arc Marine
(The ArcGIS Marine Data Model)
for the oceans, seas, and coastal regions of our planet...

Podcast from 2007 ESRI UC
(13 min.)

Arc Marine Book
and Poster
"Rt-Click, Save As" for poster link (31 Mb PDF)

Data Model Diagrams & Case Studies

Arc Marine Tutorial & Tools

Project Background / People

Links to Related Projects / Resources

Archive of Documents, Meeting PPTs

Search Here!
Learning Outcomes

- List the basic elements of a geodatabase
- Import an existing schema into an empty Arc Marine geodatabase
- Compare your data structure to that of an existing geodatabase schema
- Load data
- Create new relationships between tables
- Import tables with data already in them
- Create and load a raster catalog
- Display your data using dynamic segmentation
- Query data linked through relationships in ArcMap
Monterey Bay Species Observations, Habitats
Important Things to Consider

- Coordinate system and spatial extent
- Identifying any possible differences between the schema and your data
- Which feature classes should the data go into?
- What are the attributes of each data set?
- Do you want to relate any of your data? If so, through what key fields?

TIP: Remember to use Parameters table
- table and the associated relationships allow access to features from parameter of interest (S, T, DOC, etc.)
Arc Marine with Other Data Models
Arc Marine with Other Data Models?
Arc Hydro, IHO-S57, Weather & Climate, etc.

Super class ➔ Geometry ➔ Thematic

ESRI Classes: Feature
+Shape : esriFieldTypeGeometry

MarineFeature
-FeatureID : esriFieldTypeInteger
+FeatureCode : esriFieldTypeString

MarinePoint

MeasurementPoint
-CruiseID : esriFieldTypeInteger

FeaturePoint
[GeometryType = esriGeometryPoint]

TimeSeriesPoint
[GeometryType = esriGeometryPoint]

InstantaneousPoint
[GeometryType = esriGeometryPoint]
-Timestamp : esriFieldTypeDate
-ZValue : esriFieldTypeDouble
-SurveyID : esriFieldTypeInteger
-SeriesID : esriFieldTypeInteger
«SubtypeField»-PointType : esriFieldTypeInteger = 1

Instant
-PointType : esriFieldTypeInteger = 1

Sounding
-PointType : esriFieldTypeInteger = 2

Survey
-PointType : esriFieldTypeInteger = 3

LocationSeries
-PointType : esriFieldTypeInteger = 4
Arc Marine with Other Data Models?

See also Nyerges et al., Coastal Zone ‘07 Paper

Constructing a Coastal Data Model for Puget Sound: A Classroom Experience:
ArcGIS Resource Centers

Made for user communities.
An expanded data models site.
Provide a single location for your ArcGIS project.
No needs to collect bits and pieces of information elsewhere.

http://resources.esri.com
ArcGIS Resource Centers

Build Rich Internet Applications

The new ArcGIS API for Flex allows you to create Rich Internet Applications with the power of ArcGIS Server.

Learn More

<table>
<thead>
<tr>
<th>Products</th>
<th>Functions</th>
<th>User Communities</th>
<th>Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>ArcGIS Desktop</td>
<td>ArcGIS Online</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>ArcGIS Server</td>
<td>Geoprocessing</td>
<td>-</td>
<td>Business Analyst Suite</td>
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<tr>
<td>ArcGIS Engine</td>
<td>Geodatabase &amp; ArcSDE</td>
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<td>ArcGIS Explorer</td>
<td>Image Management</td>
<td>-</td>
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<td>ArcGIS Mobile</td>
<td>CAD Integration</td>
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<td>ArcIMS</td>
<td>Mapping &amp; Visualization</td>
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<td>Map Templates</td>
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<td>Water Utilities</td>
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<td>Java</td>
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<td>Public Safety</td>
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</table>
Welcome to the Resource Center for Water Utilities Management

This Web site is for the ArcGIS water, wastewater, and stormwater utility community. It provides useful templates and best practice information enabling you to implement ArcGIS to manage your water utility information, perform your daily operations, and support your long-term planning.

The Water Facilities Resource Center is the place for you to:

- Learn how to implement ArcGIS for managing water utilities
- Download and configure ArcGIS templates that can help you get started
- Communicate with:
  - Other Water utilities users like you
  - The ESRI Water Utilities team

About ArcGIS for Water Utilities

This Web site provides application templates that will help you:

- Manage your water networks and other assets
- Plan for your short-term operations and long-term needs
- Effectively share information with and manage your mobile workforce
- Maintain operational awareness and foster communication across your organization

Helpful Resources

- Read the Water Utilities Blog
- Participate in the Water, Wastewater & Stormwater Community Forums
- View materials from the 2008 ESRI Water Utilities Seminar
- Read the Water Writes newsletter
- See News and Events for water utilities
- View Case Studies for water utilities

http://resources.esri.com/WaterUtilities/
Template Gallery

Add An Entry

<table>
<thead>
<tr>
<th>name</th>
<th>rating</th>
<th>date added</th>
<th>product version</th>
<th>author</th>
<th>downloads</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Distribution Model for use with ArcGIS for AutoCAD</td>
<td>0 Ratings</td>
<td>Jun 03 2009</td>
<td>9.3</td>
<td>donk</td>
<td>68</td>
</tr>
<tr>
<td>These sample AutoCAD drawings were created with the ArcGIS EXPORT TO CAD tool using the sample geodatabase included in the Water Distribution Network Editing template found here: <a href="http://resources.esri.com/waterutilities/index.cfm?fa=codeGalleryDetails&amp;scriptID=16039">http://resources.esri.com/waterutilities/index.cfm?fa=codeGalleryDetails&amp;scriptID=16039</a>. Included in the download is the data dictionary from the Water Distribution Network Editing Template. To use these template drawings you will need to use a version of AutoCAD has been enhanced...</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Water Distribution Operations Dashboard</td>
<td>5 Ratings</td>
<td>Feb 13 2009</td>
<td>9.3</td>
<td>ArcGISTeamWater</td>
<td>947</td>
</tr>
<tr>
<td>The Water Distribution Operations Dashboard Template is an industry-specific configuration of ArcGIS Server and ESRI's Sample Flex Viewer that provides a high-level view into the health and operations of a water utility. It provides relevant basemaps and operational layers from several sources, and provides a series of information popups and reports so concise map-centric content can be visualized and used...</td>
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<tr>
<td>Water Distribution Network Editing</td>
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<td>9.3</td>
<td>ArcGISTeamWater</td>
<td>1248</td>
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<tr>
<td>The Water Distribution Network Editing Template is an industry-specific...</td>
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</table>
Tools and Initiatives to Advance Arc Marine

- BIDI and GeoDI projects in Ireland
- Ecosystem-Based Management (EBM) Tools Network
Additional Arc Marine Projects

Coastal and Marine Resources Centre
Ionaí Acmhainní Cósta is Mhara

BIDI: Biological Data Integration

- Project Status: active
- Start Year: 2005
- End Year: 2007
- Funding Body: Marine Institute
- Geographic Area: Irish coastline
- Local Study Area: Rutgers marine field station

Project Co-Ordinator: Valerie Cummins
CMRC Contact: Yassine Lassoued

Abstract
The project aims to review existing biological datasets within the Marine Institute, analyse them with respect to integration with the Arc Marine Data Model and assess the scientific value of undertaking this process.
The spatial extent of Marine Institute datasets

<table>
<thead>
<tr>
<th>MARINEID</th>
<th>MARINECODE</th>
<th>ICESDIV</th>
<th>RECORDEDTIME</th>
<th>XLOCATION</th>
<th>YLOCATION</th>
<th>BOTTOMDEPTH</th>
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</table>
GeoDI (Geological & Geophysical Data Integration) is a three-year project funded by NDP under the Sea Change programme.

The objective of the GeoDI project is to derive maximum value from the national data acquisition effort to date and to allow future data to be integrated easily. This can be achieved by integrating datasets and advancing the data management methods to derive a holistic and more sophisticated view of change in the status of the marine environment. The GeoDI project aims to address this challenge by examining the critical issues involved in the integration of Irish marine geoscientific datasets and assessing tools and services for enhanced analyses of geoscientific data.
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(The ArcGIS Marine Data Model)
for the oceans, seas, and coastal regions of our planet...

Podcast from 2007 ESRI UC (12 min.)

Arc Marine Book and Poster
"Right-click, Save As" for poster link (31 Mb PDF)

Data Model Diagrams & Case Studies

Arc Marine Tutorial & Tools

Project Background / People

Links to Related Projects / Resources

Archive of Documents, Meeting PPTs
Open Discussion

Session Evaluations Reminder:
*Please turn in your session evaluations.*

... Thank you!
Thanks for participating!

Dawn Wright dawn@dusk.geo.orst.edu
Katsura Iizuka kiizuka@esri.com