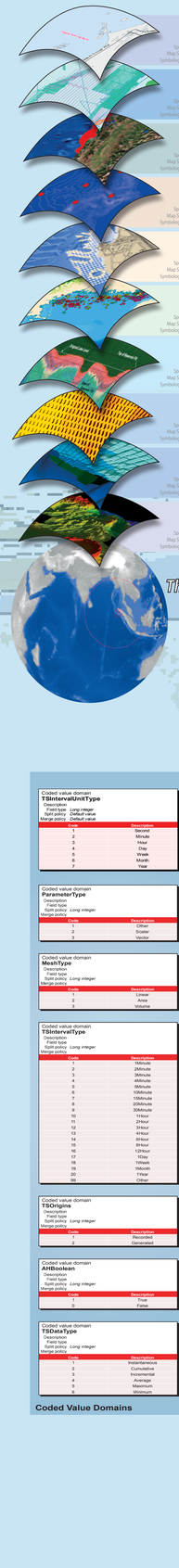
ARC MARINE: THE ARCGIS MARINE DATA MODEL



The Thematic Layers

Layer **Shorelines**
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 untethered, autonomous
Data Source Shipboard or vehicle GPS logs 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 ~10 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 trawls, marine protected area boundaries, habitats, drifter tracks, oil spills
Data Source Derived from survey maps/charts, legal definitions, clipping/masking; 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 moored 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 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-temp-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 ~10-50 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 species with varying time intervals
Data Source Telemetry recorders and transmitters, animal/bird sightings, ship-mounted ADCP
Representation Multipoint features, often with line symbols to establish animal track
Spatial Relationships Multipoints 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 ~10-50 m
Symbology and Annotation Point and line symbology annotated with species type

Layer **Survey Transects**
Map Use Geomorphic, sediment transport, or hydrodynamic analyses along profiles or cross-sections, subsurface profiling
Data Source Derived from bathymetry, scientific mesh, one-dimensional hydrological models; measured by sub bottom profilers
Representation Interpolated, linear profile view of a surface or subsurface
Spatial Relationships Cross-sections perpendicular to shoreline or flowline; profiles at varying azimuths to align with surface control point or baseline
Map Scale and Accuracy Typical map scale is 1:24,000; locational accuracy ~10 m
Symbology and Annotation Line symbology for surface often for subsurface tone, contrast and balance of grayscale according to data values

Layer **Scientific Mesh**
Map Use Mapping output of finite element models, hydrodynamic and hydrologic models, sea surface temperatures
Data Source Numerical models and satellite data sets
Representation Regularly or irregular spaced point features, scalars or vectors; raster, TIN model
Spatial Relationships Attribute values can be used to create interpolated surfaces of magnitude with point values representing direction
Map Scale and Accuracy Map scale varies and locational accuracy can range from 1 m to 1 km depending on data
Symbology and Annotation Rendered with graduated point symbols to reflect magnitude; rotated to represent direction; may be animate

Layer **Mesh Volumes**
Map Use Pelagic or open water environment
Data Source Derived features from scientific meshes, point data from stationary, fixed, suspended, or floating devices
Representation Extended cube or hexagonal pillars stacked to represent volumetric areas
Spatial Relationships Volumes can be related to mesh points between varying depths, or from bathymetry to sea surface
Map Scale and Accuracy Map scale varies and locational accuracy depends on data type and resulting volume calculation
Symbology and Annotation May be polygonal with varying 3D base heights; applied transparency

Layer **Bathymetry and Backscatter**
Map Use Terrain analysis, benthic habitat classification, morpho-tectonic interpretation, cartographic background
Data Source Interpolation of irregularly- or regularly-spaced single or multibeam soundings, LIDAR
Representation Raster with depth or backscatter intensity, TIN surface model
Spatial Relationships Coincident with point from which it was derived, or interpolated; if raster, each cell has a depth, if TIN each face joins to form surface
Map Scale and Accuracy Typical map scales and locational accuracies for shallow regions are 1:24001 m, or 1:20,000-1:50,000 100 m for deep ocean
Symbology and Annotation Usually shown with graduated colors; may be overlain with contours

Coded Value Domains

Coded value domain
TSIntervalUnitType
Description:
Field type *Long integer*
Split policy *Long integer*
Merge policy *Default value*

Code	Description
1	Second
2	Minute
3	Hour
4	Day
5	Week
6	Month
7	Year

Coded value domain
ParameterType
Description:
Field type *Long integer*
Split policy *Long integer*
Merge policy

Code	Description
1	Other
2	Scalar
3	Vector

Coded value domain
MeshType
Description:
Field type *Long integer*
Split policy *Long integer*
Merge policy

Code	Description
1	Linear
2	Area
3	Volume

Coded value domain
TSIntervalType
Description:
Field type *Long integer*
Split policy *Long integer*
Merge policy

Code	Description
1	1Minute
2	2Minute
3	3Minute
4	4Minute
5	5Minute
6	10Minute
7	15Minute
8	20Minute
9	30Minute
10	1Hour
11	2Hour
12	3Hour
13	4Hour
14	6Hour
15	8Hour
16	12Hour
17	1Day
18	1Week
19	1Month
20	1Year
99	Other

Coded value domain
TSOrigins
Description:
Field type *Long integer*
Split policy *Long integer*
Merge policy

Code	Description
1	Recorded
2	Generated

Coded value domain
AHBoolean
Description:
Field type *Long integer*
Split policy *Long integer*
Merge policy

Code	Description
1	True
0	False

Coded value domain
TSDataType
Description:
Field type *Long integer*
Split policy *Long integer*
Merge policy

Code	Description
1	Instantaneous
2	Cumulative
3	Incremental
4	Average
5	Maximum
6	Minimum

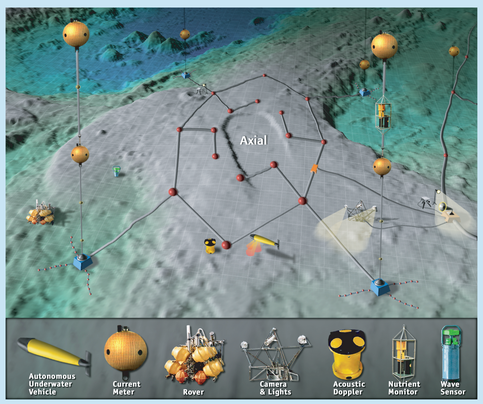
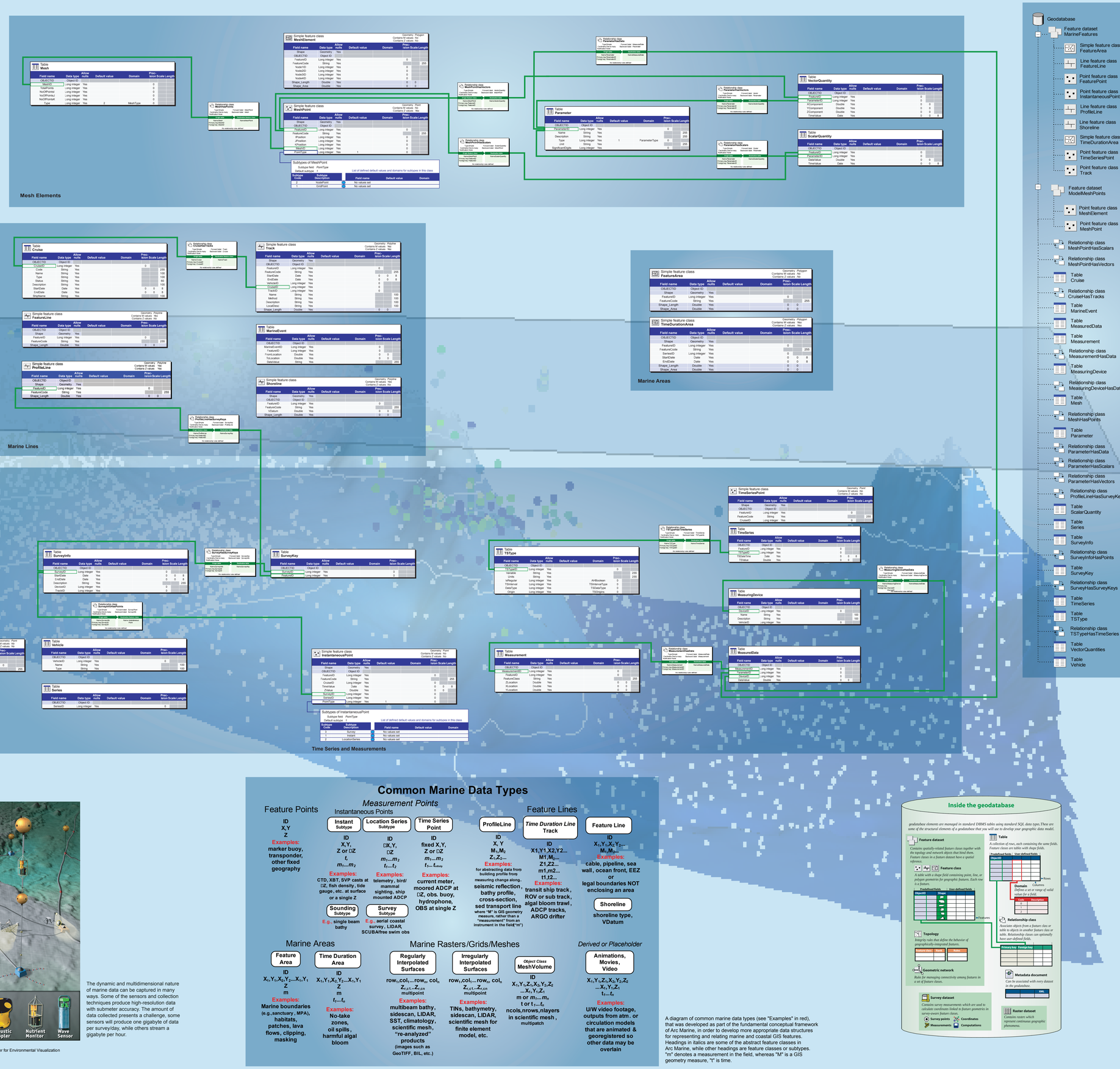


Image courtesy of the Neptune Project, www.neptune.washington.edu, University of Washington Center for Environmental Visualization

The dynamic and multidimensional nature of marine data can be captured in many ways. Some of the sensors and collection techniques produce high-resolution data with submeter accuracy. The amount of data collected presents a challenge, some sensors will produce one gigabyte of data per survey/day, while others stream a gigabyte per hour.



Geodatabase
- Feature dataset MarineFeatures
  - Simple feature class FeatureArea
  - Line feature class ProfileLine
  - Point feature class FeaturePoint
  - Point feature class InstantaneousPoint
  - Line feature class Shoreline
  - Simple feature class TimeDurationArea
  - Point feature class TimeSeriesPoint
  - Point feature class Track
- Feature dataset ModelMeshPoints
  - Point feature class MeshElement
  - Point feature class MeshPoint
- Relationship class MeshPointHasScalars
- Relationship class MeshPointHasVectors
- Table Cruise
- Relationship class CruiseHasTracks
- Table MarineEvent
- Table MeasuredData
- Table Measurement
- Relationship class MeasurementHasData
- Table MeasuringDevice
- Relationship class MeasuringDeviceHasData
- Table Mesh
- Relationship class MeshHasPoints
- Table Parameter
- Relationship class ParameterHasData
- Relationship class ParameterHasScalars
- Relationship class ParameterHasVectors
- Relationship class ProfileLineHasSurveyKeys
- Table ScalarQuantity
- Table Series
- Table SurveyInfo
- Relationship class SurveyInfoHasPoints
- Table SurveyKey
- Relationship class SurveyHasSurveyKeys
- Table TimeSeries
- Table TSType
- Relationship class TSTypeHasTimeSeries
- Table VectorQuantities
- Table Vehicle

Common Marine Data Types

Feature Points

ID
X,Y
Z

Examples:
marker buoy, transponder, other fixed geography

Measurement Points

Instantaneous Points

Instant Subtype

ID
X,Y,
Z or DZ
t_i
$m_1...m_2$

Examples:
CTD, XBT, SVP casts at DZ, fish density , tide gauge, etc. at surface or a single Z

Location Series Subtype

ID
DX,Y,
DZ
$m_1...m_2$
$t_1...t_2$

Examples:
telemetry , bird/ mammal sighting, ship mounted ADCP

Time Series Point

ID
fixed X,Y,
Z or DZ
$m_1...m_2$
$t_1...t_{end}$

Examples:
current meter, moored ADCP at DZ, obs. buoy, hydrophone, OBS at single Z

Sounding Subtype

E.g., single beam bathy

Survey Subtype

E.g., aerial coastal survey , LIDAR, SCUBA/free swim obs

Feature Lines

ProfileLine

ID
X, Y
M_1,M_2
$Z_1,Z_2...$

Examples:
for abstracting data from building profile from measuring change along-.
seismic reflection, bathy profile, cross-section, sed transport line
where "M" is GIS geometry measure, rather than a "measurement" from an instrument in the field("m")

***Time Duration Line* Track**

ID
X1,Y1,X2,Y2...
M1,M2,...
Z1,Z2...
m1,m2...
$t_1,t_2...$

Examples:
transit ship track, ROV or sub track, algal bloom trawl, ADCP tracks, ARGO drifter

Feature Line

ID
$X_1,Y_1,X_2,Y_2...$
$M_1,M_2...$

Examples:
cable, pipeline, sea wall , ocean front, EEZ or legal boundaries NOT enclosing an area

Shoreline

shoreline type, VDatum

Marine Areas

Feature Area

ID
$X_1,Y_1,X_2,Y_2...X_1,Y_1$
Z
m

Examples:
Marine boundaries (e.g.,sanctuary , MPA), habitats, patches, lava flows, clipping, masking

Time Duration Area

ID
$X_1,Y_1,X_2,Y_2...X_1,Y_1$
Z
m
$t_1...t_n$

Examples:
No-take zones, oil spills , harmful algal bloom

Marine Rasters/Grids/Meshes

Regularly Interpolated Surfaces

$row_1,col_1...row_m$ col_n
$Z_{r1,c1}...Z_{r1,cn}$
multipoint

Examples:
multibeam bathy, sidescan, LIDAR, SST, climatology , scientific mesh, "re-analyzed" products
(images such as GeoTIFF, BIL, etc.)

Irregularly Interpolated Surfaces

$row_1,col_1...row_m$ col_n
$Z_{r1,c1}...Z_{r1,cn}$
multipoint

Examples:
TINs, bathymetry, sidescan, LIDAR, scientific mesh for finite element model, etc.

Object Class MeshVolume

ID
X_1,Y_1,Z_1,X_2,Y_2,Z_2
$...X_1,Y_1,Z_1$
m or $m_1...m_n$
t or $t_1...t_n$

ncols,nrows,nlayers in scientific mesh ,
multipatch

Derived or Placeholder

Animations, Movies, Video

ID
X_1,Y_1,Z_1,X_2,Y_2,Z_2
$...X_1,Y_1,Z_1$
$t_1...t_n$

Examples:
U/W video footage, outputs from atm . or circulation models that are animated & georegistered so other data may be overlain

A diagram of common marine data types (see "Examples" in red), that was developed as part of the fundamental conceptual framework of Arc Marine, in order to develop more appropriate data structures for representing and relating marine and coastal GIS features. Headings in *italics* are some of the abstract feature classes in Arc Marine, while other headings are feature classes or subtypes. "m" denotes a measurement in the field, whereas "M" is a GIS geometry measure, "t" is time.