# Progress in the Formulation of the S-111 Surface Current Data Product

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- Characteristics of Surface Current Data
- Definition of the SC Data Product
- Next steps

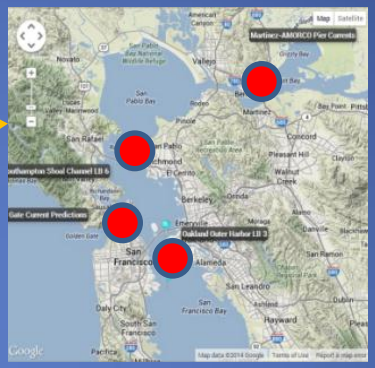
# Origins of Surface Current Data

- Observations: Real-time and Historical
  - *In situ* current meters (fixed, drifting)
  - Coastal radar
- Predictions: Astronomical Tide Only
  - Single-point time series using harmonic constants
  - Hydrodynamic model-based
  - Tidal atlas
- Forecasts: Includes Meteorology
  - Numerous points
  - Hydrodynamic model-based
  - Updated several times per day
  - Includes analysis

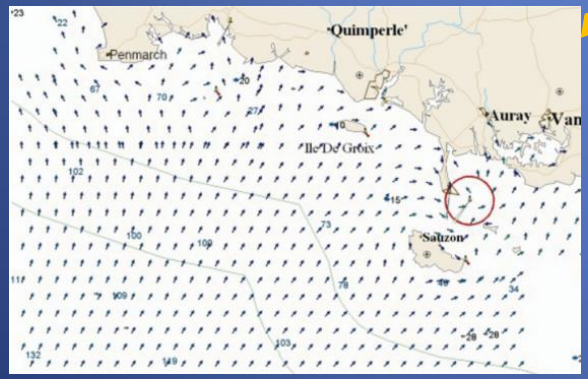
# From Data to S-100 Features: Where do Currents Fit?

Selected Primitives:

- point
- curve
- surface
- coverage: image, grid, or point set



Location of a tidal current prediction or real-time observation

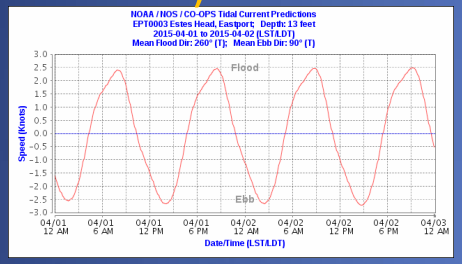



(a) Regular, geo-rectified Grid


(b) Point set (cf. Unstructured Grid)

# Common Data Organization Types

## A. TIME SERIES:
## Single Point, Multiple Times (R/T Obs, Historical Obs, Prediction)




# Station ID: cb1101
# # Orientation: Down (Buoy-Mounted)
# # Time Zone: UTC
# # Approx. Depth: Near Surface
# # Blank rows indicate missing data. See our data
# # disclaimer online.

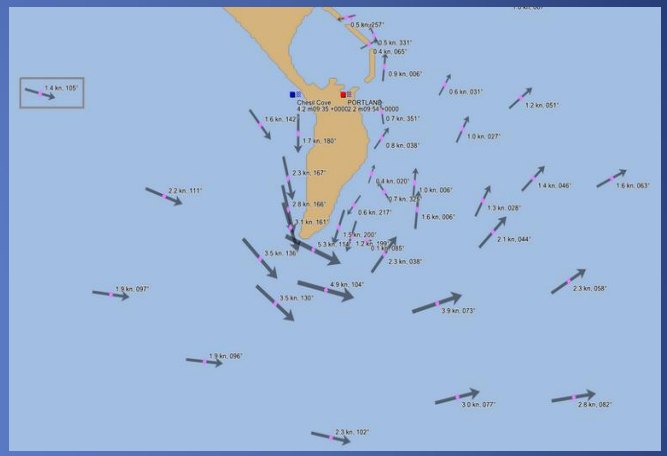
| # # Date | Time | Speed (knots) | Dir (true) |
|---|---|---|---|
| # 2014-12-01 | 00:00:00 | 1.08 | 215 |
| # 2014-12-01 | 00:06:00 | 1.00 | 225 |
| # 2014-12-01 | 00:12:00 | 0.83 | 226 |
| # 2014-12-01 | 00:18:00 | 0.73 | 230 |
| # 2014-12-01 | 00:24:00 | 0.80 | 223 |
| # 2014-12-01 | 00:30:00 | 0.77 | 236 |
| # 2014-12-01 | 00:36:00 | 0.73 | 229 |
| # 2014-12-01 | 00:42:00 | 0.61 | 224 |

## B. GRIDDED FIELDS:
## Multiple Points, Single Time (Fcst, Analysis, Codar)


Dataset 'speed(knots)'
Size: 500x325
MaxSize: 500x325
Datatype: H5T_IEEE_F32LE (single)
ChunkSize: 1x325
Filters: deflate(9)
FillValue: 0.000000
Attributes:
'organization': 'Center Canadian Meteorological Service - Montreal (RSMC) (54) '
'Delta_Longitude': '0.02993999933078885 '
'Delta_Latitude': '0.019938461092802194 '
'forecastDateTime': '20140611_180000 '
'Product': 'Type: Forecast products Status: Operational products '
'Minimum_Latitude': '45.5 '
'Maximum_Latitude': '51.97999985516071 '
'Maximum_Longitude': '-56.030000334605575 '
'Number_Of_Cells_South_North': '325 '
'Minimum_Longitude': '-71.0 '
'Number_Of_Cells_West_East': '500 '
'generatedDateTime': '20140611_000000 '
'units': 'mm/s '
speed(knots) =
0, 0, 0, 0.5191959, 0.5159838, 0.5159435, 0.5186388,
0.5209069, 0.5167338, 0.5114825, 0.4738558, 0.378551, 0.2911682,
0.204335, 0.1294665, ...

# Digital Tidal Current Atlas Data

| | Speed | | Direction | |
|---|---|---|---|---|
| Hour | Neap | Spring | Neap | Spring |
| 1 | 0.924 | 0.991 | 234.0 | 232.8 |
| 2 | 0.991 | 1.047 | 235.4 | 233.5 |
| 3 | 1.015 | 1.104 | 233.1 | 234.8 |
| 4 | 0.939 | 1.132 | 233.4 | 233.0 |
| 5 | 0.447 | 0.947 | 233.7 | 233.3 |
| 6 | 0.302 | 0.061 | 232.8 | 200.1 |
| 7 | 0.444 | 0.292 | 232.5 | 56.0 |
| 8 | 0.562 | 0.044 | 232.5 | 68.2 |
| 9 | 0.596 | 0.469 | 232.4 | 231.2 |
| 10 | 0.620 | 0.662 | 232.5 | 231.3 |
| 11 | 0.705 | 0.779 | 232.7 | 231.6 |
| 12 | 0.797 | 0.886 | 233.0 | 232.1 |
| 13 | 0.876 | 0.967 | 233.5 | 232.6 |



Typical current vector plot for one time

Using the predicted tide range/current for each day, these points can be converted into:

- A time series at multiple points
- or
- A point set grid at multiple times

But on land or aboard ship?

# Generalized Approach to Organization of Data:
## Multiple Regular Grids in HDF5 Format

### Gridded Data:

Time =20141201+000000
Speed=0.519, 0.518, 0.515, ..
Dir=32.7, 3 0.3, 27.8, …

Time=20141201+000600
Speed=0.523, 0.525, 0.516, ..
Dir=32.9, 30.4, 27.7, …

(requires a sequencing rule to assign values to specific grid points)

### Single-Point Data:
(a 1 x 1 grid)

Time =20141201+000000
Speed=1.08
Dir=215

Time=20141201+000600
Speed=1.00
Dir=225

# Data Product Structure (Proposed)

Surface Current Data Product for multiple times at a single location or one forecast region

| Metadata Block |
|---|

| Metadata for Time 1 |
|---|
| Surface current speed at Time 1 |
| Surface current direction at Time 1 |
| Optional data at Time 1 |

| Metadata for Time 2 |
|---|
| Surface current speed at Time 2 |
| Surface current direction at Time 2 |
| Optional data at Time 2 |

Optional data:

- Water level at current
- Speed uncertainty
- Direction uncertainty

## Product Metadata

| N | DESCRIPTION | UNITS | DATA TYPE | PROPOSED VARIABLE NAME |
|---|---|---|---|---|
| 1 | Country of Origin | NA | CodeList | Country |
| 2 | Primary Producing Agency Information | NA | CodeList | Producing_Agency |
| 3 | Secondary Producing Agency Information | NA | Text | Secondary_Agency |
| 4 | Name of Geographic Region | NA | Text | Geographic_Region |
| 5 | Name of Geographic Subregion | NA | Text | Geographic_Subregion |
| 6 | Minimum Longitude of Area | Arc Degrees | Real | West_Bound_Long |
| 7 | Maximum Longitude of Area | Arc Degrees | Real | East_Bound_Long |
| 8 | Minimum Latitude of Area | Arc Degrees | Real | South_Bound_Lat |
| 9 | Maximum Latitude of Area | Arc Degrees | Real | North_Bound_Lat |
| 10 | Time of Data Product Production | Y,M,D,H,M,S | Date-Time | T_product |
| 11 | Valid Time of First Value | Y,M,D,H,M,S | Date-Time | T_valid1 |
| 12 | Valid Time of Last Value | Y,M,D,H,M,S | Date-Time | T_valid2 |
| 13 | Number of Individual Time Values | None | Integer | K_Sets |
| 14 | Data Type (1=historical obs, 2=real-time observation, 3=astronomical prediction, 4=analysis, 5=hindcast, 6=forecast) | None | Enumeration | Index_Data_Type |
| 15 | Name of Station or Grid | NA | Text | - |
| 16 | Methodology: instrument or model | NA | Text | - |
| 17 | Grid Origin Longitude | Arc Degrees | Real | Origin_Longitude |
| 18 | Grid Origin Latitude | Arc Degrees | Real | Origin_Latitude |
| 19 | Grid Spacing Longitudinal | Arc Degrees | Real | Delta_Longitude |
| 20 | Grid Spacing Latitudinal | Arc Degrees | Real | Delta_Latitude |
| 21 | Land Mask/Missing Data Value (e.g., -1.0) | (Varies) | Real | Land_Mask_Value |
| 22 | Index for Layer Averaging or Depth of Current (1=layer, 2=depth below surf, 3=depth below fixed datum) | None | Enumeration | Index_Depth_Ref |
| 23 | Layer Thickness (if above index=1) or Depth of Current Below Datum (if above index=2,3) | Meters | Real | Surcur_Depth |
| 24 | Datum for Surface Elevation (if above index=3, then 0=unk, 1=LAT, 2=MLLW, 3=bottom, etc.) | None | Enumeration | Index_SurfDatum |
| 25 | Index for Surface Elevation (0=no,1=array) | None | Enumeration | Index_Surface_Elev |
| 26 | Datum for Surface Elevation (if above index=1, then 0=unk, 1=LAT, 2=MLLW, 3=bottom, etc.) | None | Enumeration | Index_ElevDatum |
| 27 | Horizontal Position Uncertainty | Meters | Real | Unc_Horizpos |
| 28 | Vertical Position Uncertainty | Meters | Real | Unc_Vertpos |
| 29 | Data Uncertainty Index (0=unk,1=const, 2=array) | None | Enumeration | Index_Data_Uncert |
| 30 | Speed Uncertainty Constant Value (Optional) | Meters | Real | Unc_Speed |
| 31 | Direction Uncertainty Constant Value (Optional) | Arc Degrees | Real | Unc_Direction |

# Data Delivery:
## I. A Web-based UKC System

### Dynamic Under Keel Clearance System



PROTIDE Takes Forecasts of:

- Water levels (CO-OPS Astronomical Predictions)
- Currents (CO-OPS Astronomical Predictions)
- Waves and swell height and period (NWS NSWP and CDIP Observations)
- Channel Depth (OCS 2013 Hydro Survey)
- Ship course
- Dimensions and
- Stability

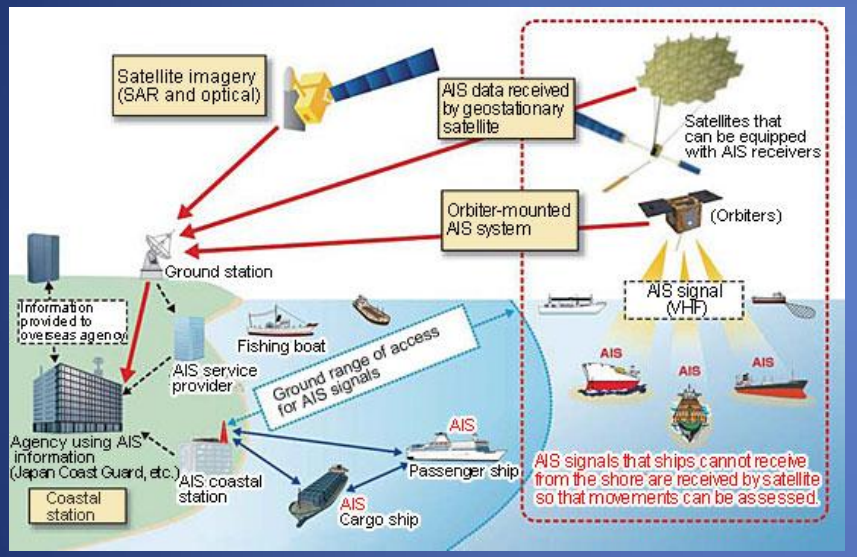
Ports of Los Angeles and Long Beach, US

Calculates anticipated roll/pitch/squat using Monte Carlo simulation to determine under keel clearance and bottom touch probability

### USES CURRENTS:

- Astronomical predictions
- Real-time observations
- Model-based forecasts

# II. An AIS-based system (Automatic Information System)




## Portion of Meteorological and Hydrographic Data AIS Application Specific Message

| Variable | Bits | Coding |
|---|---|---|
| Surface Current Speed (incl. tide) | 8 | Speed of Current measured at the sea surface, in 0.1 knot steps.<br>0.0 - 25.0 knots<br>251 = speed 25.1 knots or greater<br>255 = not available = default<br>252-254 (reserved for future use) |
| Surface Current Direction | 9 | Direction of Current at the sea surface, in 1 degree steps.<br>0 - 359 degrees<br>360 = not available = default<br>361 - 511 (reserved for future use) |
| Current Speed, #2 | 8 | Speed of Current 2 measured at a chosen level below the sea surface, in 0.1 knot steps.<br>(Same as Surface Current Speed) |
| Current Direction, #2 | 9 | Direction of Current 2, in 1 degree steps.<br>(Same as Surface Current Direction) |
| Current Measuring level, #2 | 5 | Measuring level below sea surface, in 1 metre increment.<br>0 - 30 metres<br>31 = not available = default |
| Current Speed, #3 | 8 | Speed of Current 3 measured at a chosen level below the sea surface, in 0.1 knot steps.<br>(Same as Surface Current Speed) |
| Current Direction, #3 | 9 | Direction of Current 3, in 1 degree steps.<br>(Same as Surface Current Direction) |
| Current Measuring level, #3 | 5 | Measuring level below sea surface, in 1 metre steps.<br>0 - 30 metres<br>31 = data not available = default |

# Update Frequency & Transmission Modes

| Type of Current Data | Update Interval | Number of Geo. Locations | Mode |
|---|---|---|---|
| Real-time Obs. | 0.1 hr | 1 - 10 | Radio, Internet |
| Tidal Prediction | 1 yr | 100 – 1,000 | Media |
| Model-based Forecast | 6 hr | 10,000 - 100,000 | Internet |

# Selected Remaining Issues

- Water Level at Current Grid Point
  - Is it needed?
  - Which vertical datum?
  - Connect to bathymetry?
- Uncertainty in Speed and Direction
  - How to calculate?
  - Single value or field?
- Portrayal
  - Zooming capability and spatial interpolation
  - Transparency
  - Many other issues
- On-board vs. land-based processing
  - Tidal atlas
- Reformatting
  - Originates in Official National Authorities' format
  - Convert to HDF5 product

# Areas of SC and TWL Commonality

- If surface currents are referenced to a fixed vertical datum
  - Which datum (LAT, MLLW, bottom)
  - Source of datum
- Most models and some observations produce both current and WL data at same geographic location
  - Process to provide currents can also provide WL
  - Process to provide WL could provide currents
  - If separate processes, must be consistent
- Tidal current predictions use harmonic constituents
  - Vetting of data and methods
- Joys of writing an S-100 compliant product spec