Positioning Issues Related to Seismic Data

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Applying the right tools and knowledge to complete a complex task with a predictable result!

Any position data loading is an exercise in this!

And remembering there is more than just X & Y*

Note: Geodetically this s/b Easting & Northing

What are the issues?

- **Positioning Issues:**
  - **Geodetic and projection identity**
  - **Project and point identity**
  - **Media & formats of positioning data**
  - **Precision and presentation**

If the geodesy doesn't fit, you must a quit!

Latitude	Longitude	X	Y
29 25 00.00 N	89 56 30.00 W	2,443,081.1	275,426.9
29 25 00.79 N	89 56 30.25 W	3,723,882.6	336,132.4
29 25 00.65 N	89 56 30.80 W	214,552.1	3,257,770.7
29 24 59.77 N	89 56 29.99 W	744,653.0	83,943.2

- **All these coordinates represent the exact same physical point on the Earth.**
- **They are all correct coordinates.**
- **Individually, they could also represent another point somewhere else on the Earth and still be correct.**

Intermixing misidentified coordinates can create positional errors ranging from a few feet or meters to miles or kilometers.

This is the number 1 reason for positioning differences!

If you don't know the geodetic and point identity only the coordinates, the impact can be quite serious.
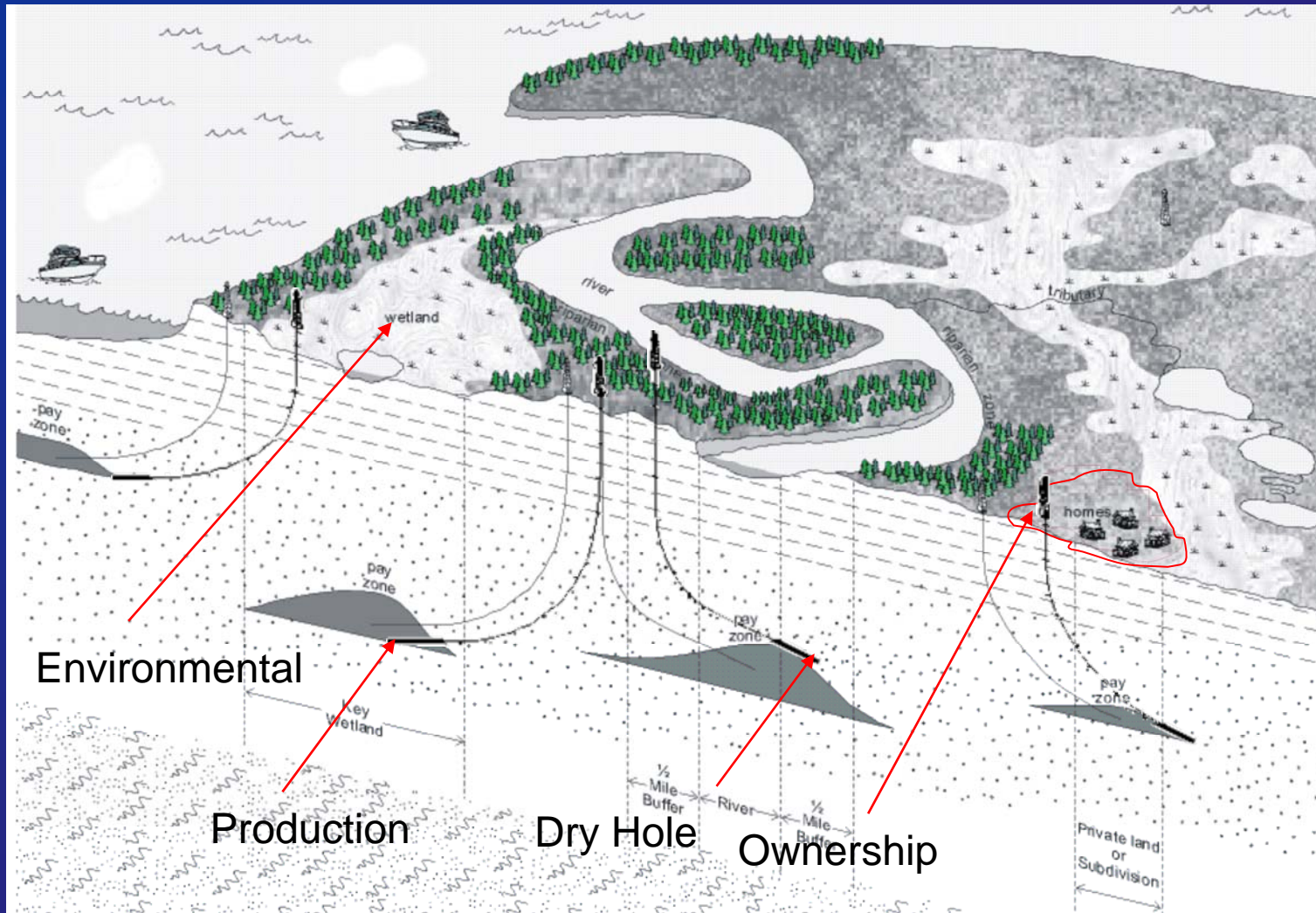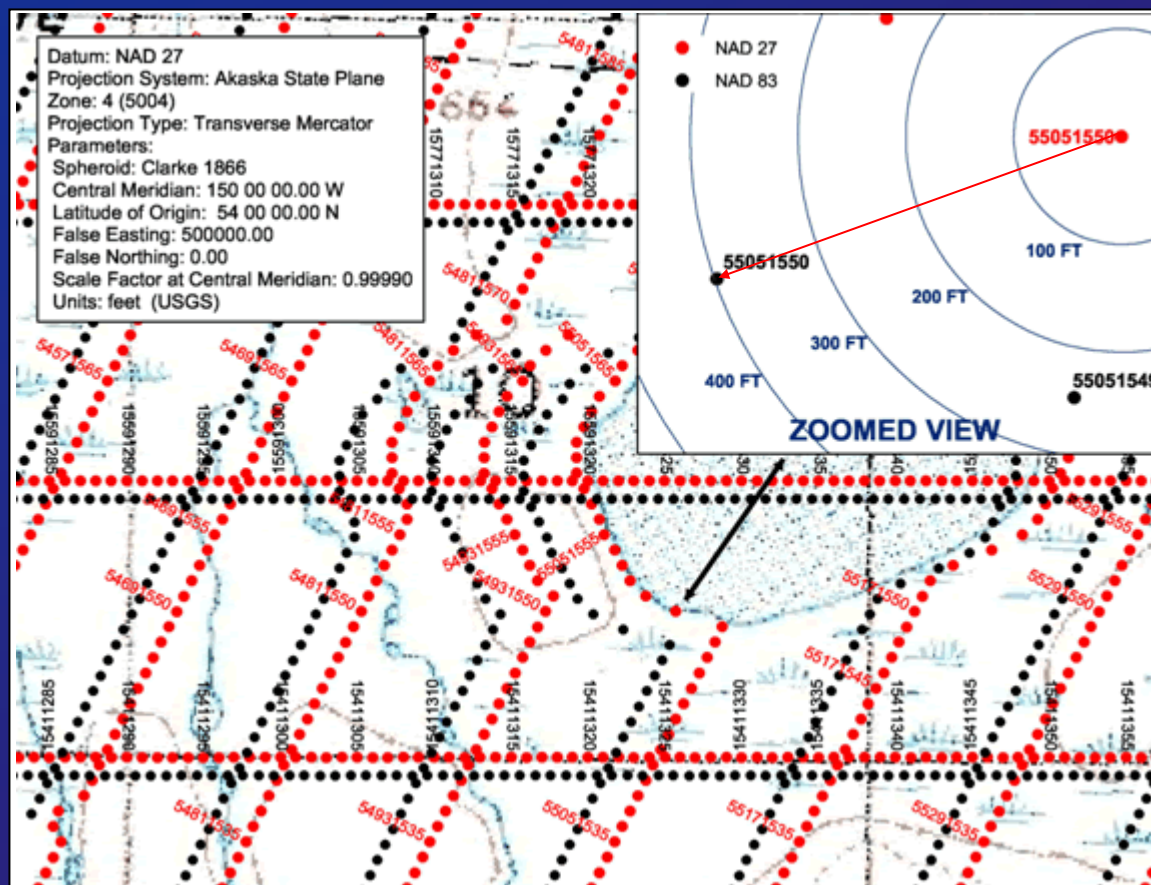
What you need to know about geodetic coordinates

- **Latitude, Longitudes must include:**
  - **Ellipsoid and Datum information**
    - **They are not synonymous.**
  - **Units (DMSH, DEC, DDM and variations).**
  - **History of any transformations since acquired.**
    - **1984 data was not acquired in WGS-84.**
    - **Libya embargo was in 1986 – Know what was used then?**

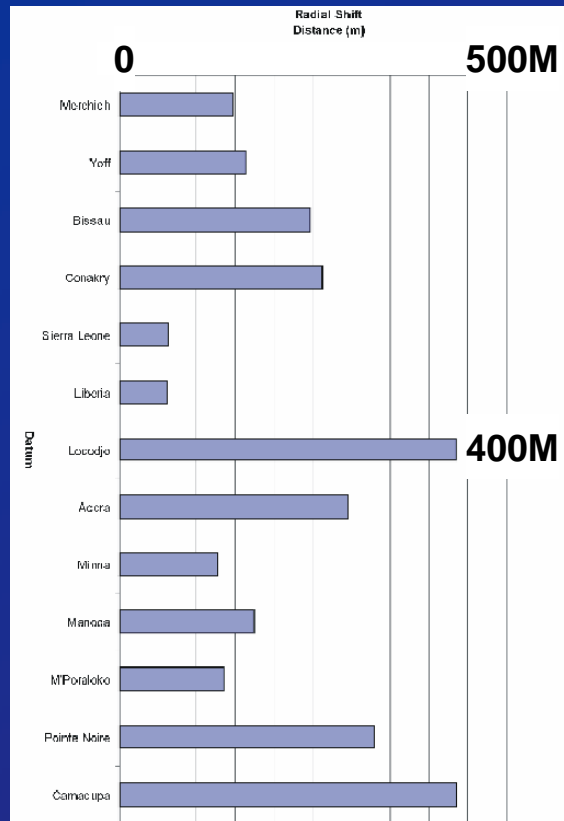**If the well data doesn't tie with the seismic, maybe some of the above was missing.**

Misidentified datums is a common problem

Mismatched datums NAD-27 Vs. NAD-83 (400' misties for this area in Alaska). Mapped NAD-83 incorrectly as NAD-27.

Datum: NAD 27
Projection System: Akaska State Plane
Zone: 4 (5004)
Projection Type: Transverse Mercator
Parameters:
Spheroid: Clarke 1866
Central Meridian: 150 00 00.00 W
Latitude of Origin: 54 00 00.00 N
False Easting: 500000.00
False Northing: 0.00
Scale Factor at Central Meridian: 0.99990
Units: feet (USGS)

● NAD 27
● NAD 83

55051550

100 FT
200 FT
300 FT
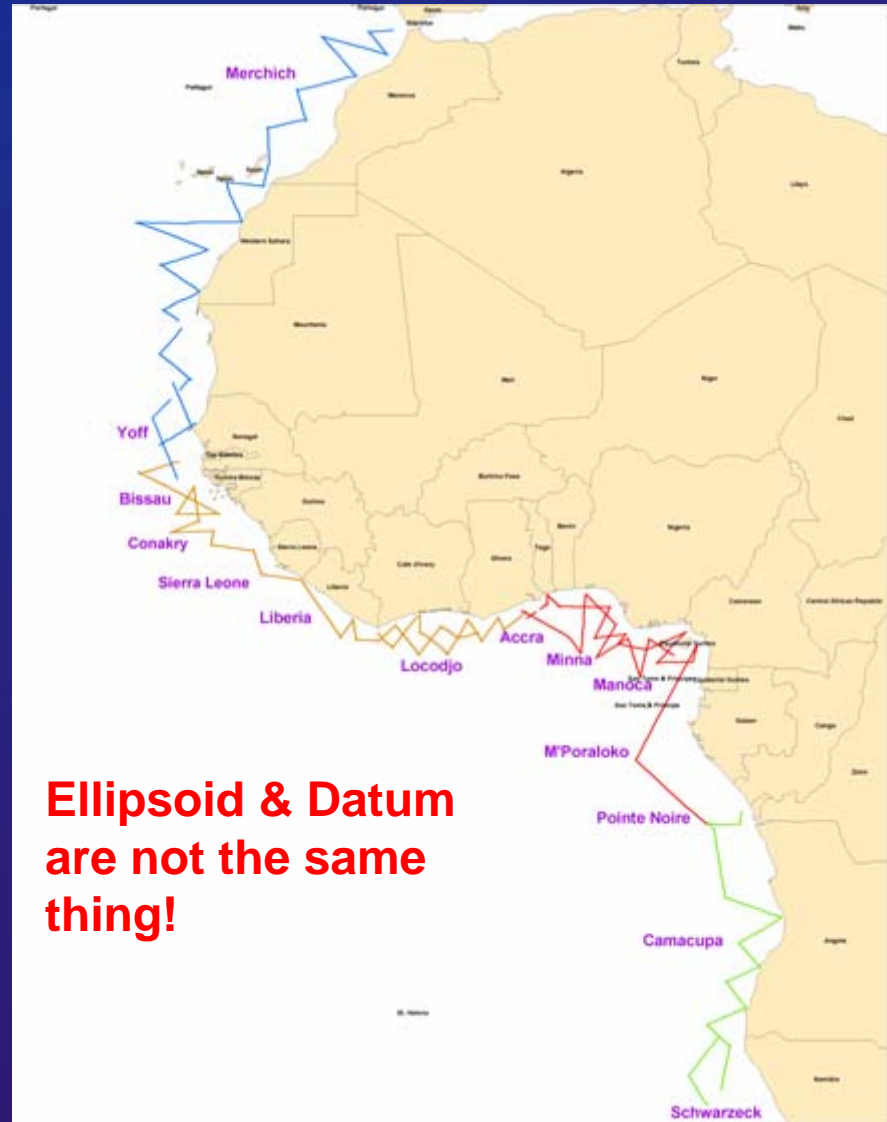400 FT

55051550

55051549

ZOOMED VIEW

You will NOT see a block shift in seismic data!
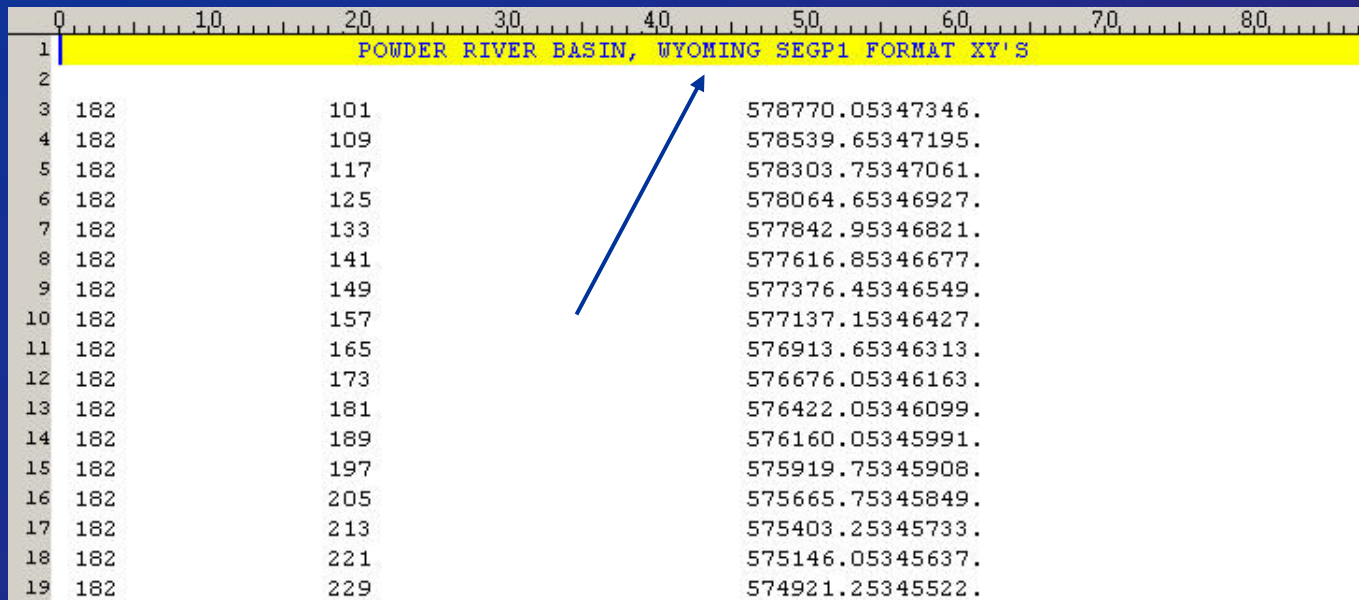
The Lat, Lons are Clarke 1880!

Variation in 13 local datums of over 400 meters. Most are referenced to Clarke 1880 IGN or RGS ellipsoid.

(Reference EPSG/OGP Database).

Ellipsoid & Datum are not the same thing!

X,Y's without proper identity can also be a problem

POWDER RIVER BASIN, WYOMING SEGP1 FORMAT XY'S

182	101	578770.05347346.
182	109	578539.65347195.
182	117	578303.75347061.
182	125	578064.65346927.
182	133	577842.95346821.
182	141	577616.85346677.
182	149	577376.45346549.
182	157	577137.15346427.
182	165	576913.65346313.
182	173	576676.05346163.
182	181	576422.05346099.
182	189	576160.05345991.
182	197	575919.75345908.
182	205	575665.75345849.
182	213	575403.25345733.
182	221	575146.05345637.
182	229	574921.25345522.

- **What do we really know about this information?**
- **I know the coordinates are not in Wyoming.**
- **The format is not SEG-P1.**
- **There is absolutely no identity telling you what the points are.**
- **And how much time would you spend figuring it out?**
- **Is this time well spent for a Geophysicist, Geologist or even a data loader?**
- **If it was UKOOA or SPS, you'd have a chance!**

What you need to know about Grid identity.

- **Grid coordinates must include:**
  - **Reference ellipsoid and preferably the datum**
  - **Projection type**
  - **Projection parameters**
  - **Projection units**
  - **Elevation and vertical datum information if land.**

Errors approaching hundreds of meters due to miss-matched coordinates.

Open mouth insert U.S. Survey foot!

- **Mismatched units US Survey Ft. Vs. Intn'l Ft. (20' misties). 3.280833333 (39.37/12), not 3.28 or 1/.3048 etc. It's a scaling error. This is GOM data UTM Zone 16.**
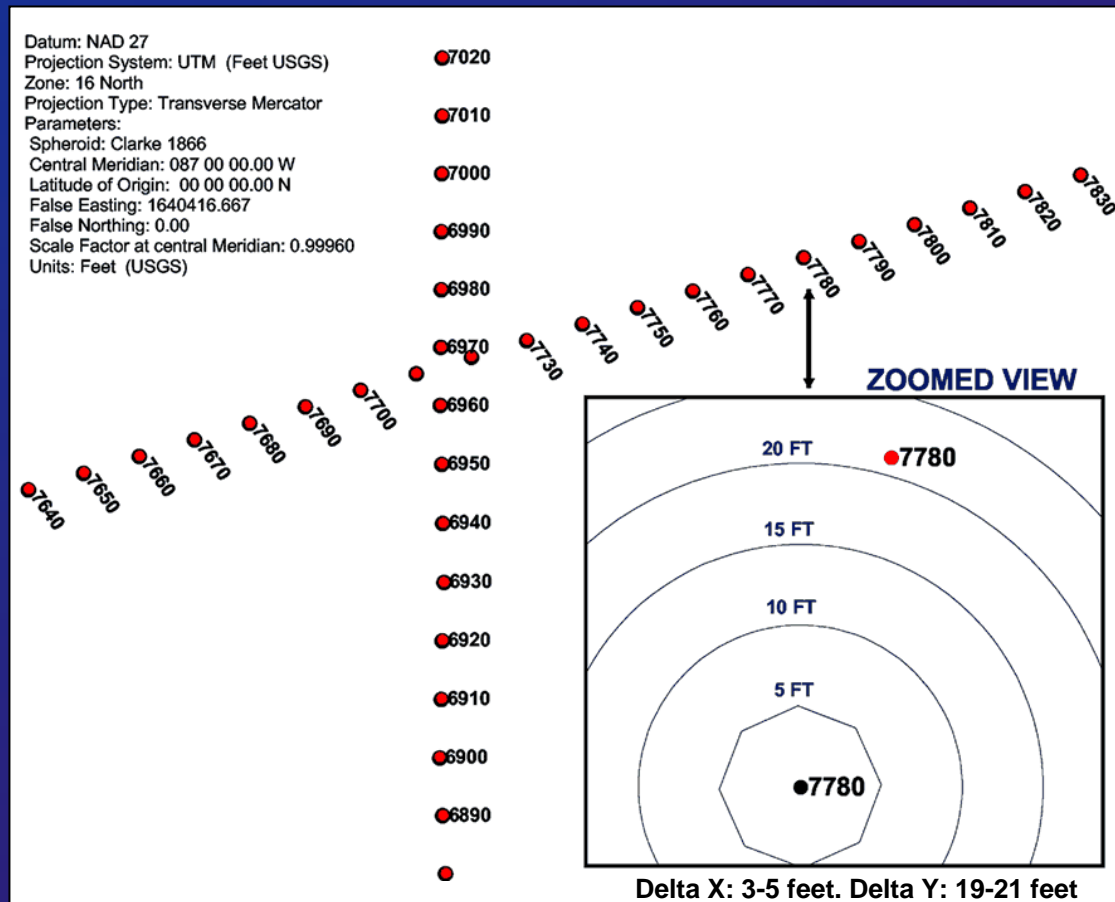
Issues relating to identity.

- **Project and point Identification**
  - **Line and shot numbering**
    - **Overlap / re-shoot schemes**
  - **Position location**
    - **Vessel, common reference point, antenna**
    - **Source and receivers**
    - **Common Mid Point, common depth point**
    - **Echo sounder**
    - **Skids, relays, re-shoots, offset**

Errors approaching hundreds of meters due to miss-matched position types.

A mistie due to incorrect point identity.

- ## Point identity
  - ### What happens If your project is Source and you add some Common Mid Point (CMP) data?
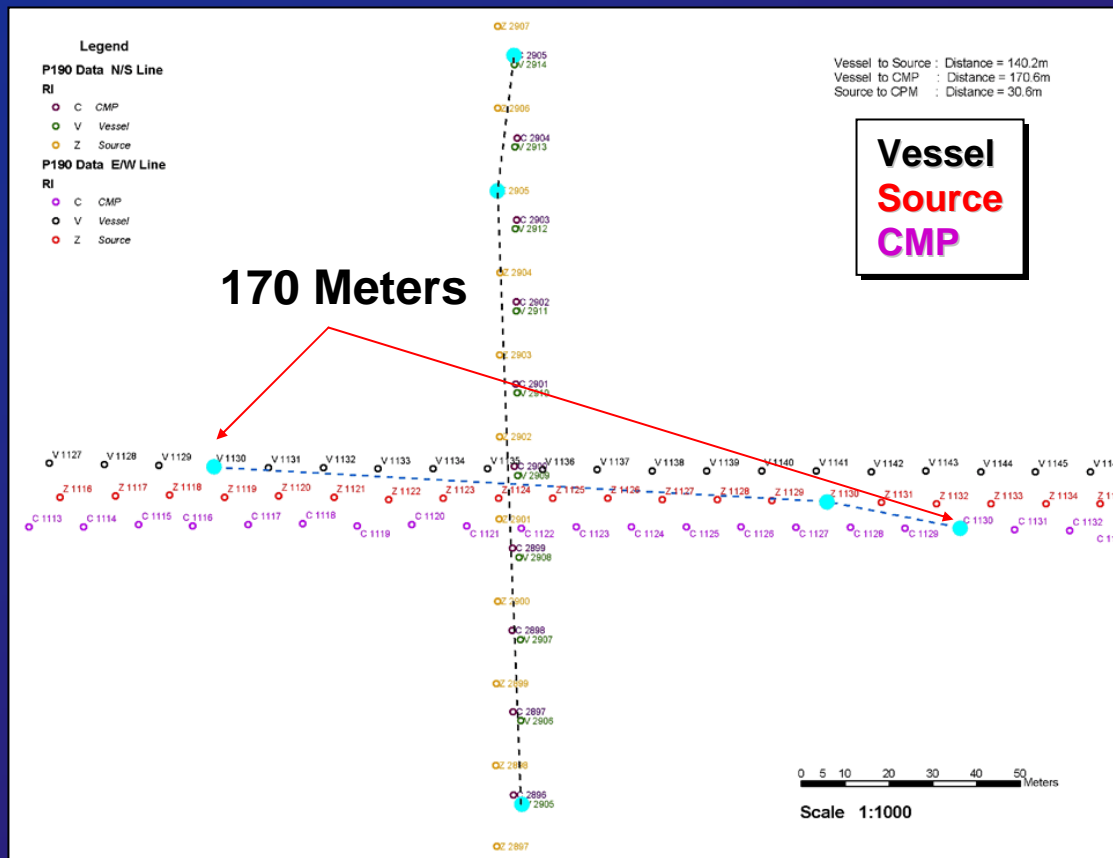
Besides shot, what else do we need?

SL4006	101	637405.9	2346.7	232199900:00:01
SL4006	102	637430.9	2346.8	232199900:00:11
SL4006	103	637455.2	2347.1	232199900:00:21
SL4006	104	637481.1	2346.8	232199900:00:31
SL4006	103A	637455.4	2347.0	232199904:01:20
SL4006	104A	637480.1	2346.4	232199904:01:30
SL4006	105A	637505.3	2346.9	232199904:01:40
SL4006	106A	637530.2	2346.6	232199904:01:50
SL4006	519A	637930.4	2346.1	232199905:00:09

4 Hrs. later

- **Line ID, Shot and X,Y may not be all that is required to do a merge with the seismic data.**

You may need a Re-shoot code or date and time to actually match the positions with the seismic.

Other in-project issues.

- **In-project**
  - **What are the coordinates?**
    - **Is the data a sub-set?**
      - **modulo**
    - **Has the data been changed?**
      - **Interpolated, transformed, scaled and rotated etc.**
      - **Migrated**
    - **How many duplicates?**
      - **Hundreds seem possible in your database?**
      - **Ever done an inventory?**
    - **What metadata does your project retain?**

200 meter rings

actual shot positions

Data derived by interpolating shots from a modulo 100 data set
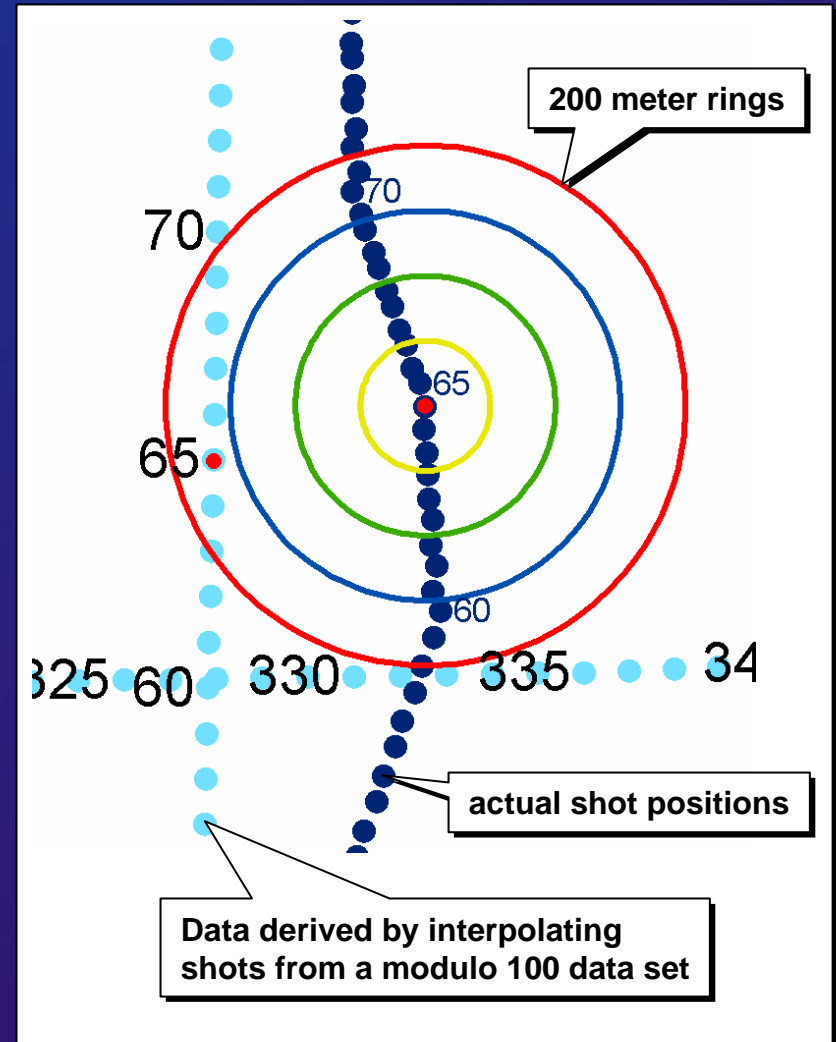
Not just the media but how its stored.

Media and Formats of positioning data

- **Digital media and structures of positioning data**
  - Many types of original media
  - ASCII vs. other encoding methods
  - Various forms of compression and archival
  - Proprietary and specialty vs. official "exchange" formats

The file is corrupt, ship me another.


```
                                fast
H0100 SURVEY AREA              1984 Survey              H0101 GENERAL SU
RVEY DETAILS    3D survey              H0102 VESSEL DETAILS        M/V Indi
an Seal          1                    H0103 SOURCE DETAILS        AIR GUN A
RRAY            1  1                   H0200 DATE OF SURVEY        Julian day
 148 through 182, 1984                H0201 DATE OF ISSUE OF TAPE   February 29
, 2005                                H0202 TAPE VERSION IDENTIFIER  CLIENT001-12
0                                     H0203 LINE PREFIX              N/A
                                      H0300 CLIENT                  CLIENT
                                      H0400 GEOPHYSICAL CONTRACTOR  Geophysical Ser
vice Incorporated                     H0500 POSITIONING CONTRACTOR   Unknown
                                      H0600 NAV PROCESSING CONTRACTOR Unknown
                              H0700 POSITIONING & ONBOARD SYS Syledis Primary - CMS
                              H0800 COORDINATE LOCATION     Center of source
                              H1000 CLOCK TIME              GMT
                              H1100 RECEIVER GROUPS PER SHOT  120
                              H1400 SPHEROID USED FOR SURVEY  NAD27      Clarke 1866  63
78206.400 294.978698H1401 SURVEY SHIFT TO WGS-84       0.0    0.0   0.0
                              H1500 SPHEROID FOR POST PLOT    NAD27      Clarke 1866  6378
206.400 294.978698H1501 POSTPLOT SHIFT TO WGS-84       0.0    0.0   0.0
                              H1600 SURVEY SHIFT TO POST PLOT   0.0    0.0   0.0
                              H1700 VERTICAL DATUM & ORIGIN  Echo Sounder         Echo Sou
nder      H1800 PROJECTION              006 Lambert Conformal Conic
          H1900 PROJECTION ZONE & HEMISPH California 5-API 040  NORTHERN HEMISPHE
sample.p190 (29%)
```

Could be record length, UNIX vs. DOS, or no CR/LF

Formats and what they mean
– **These are Seismic Standards**
- UKOOA - Generally marine
- SEG – Generally land
- SPS – Generally land and TZ/OBC

– **ASCII text formats (100's)**

– **Workstation exchange formats. (Many)**

– **E-mail me a list.**

– **Soon to be XML, GML etc.**

A typical workstation format.

Filename=TOSMAIN_MG_SMT_UTM15NAD27FEET.txt

```
2001989.165655  9884263.611151  13151.7783
2002112.196104  9884263.611140  13129.5664
2002235.226553  9884263.611130  13100.0059
2002358.257002  9884263.611119  13058.1104
2002481.287451  9884263.611108  13029.2061
2002604.317900  9884263.611098  12959.2920
2002727.348348  9884263.611087  12921.0049
2002850.378797  9884263.611077  12882.7500
2002973.409246  9884263.611066  12844.4629
2003096.439695  9884263.611055  12806.1758
```

A 1,000,000th of a foot precision?

Without the file name what do we know about this data?
What about in 5 years when the project is revisited?
How would you label the map?

What is UKOOA?

UKOOA: **United Kingdom Offshore Operator's Association**

- **De-facto standard for many positioning formats**
- **These relate to seismic**
  - **UKOOA P1 is for the exchange of positioning data**
    - **P1/78 (many), P1/84, P1/90 (current)**
    - **May have many position types**
  - **UKOOA P2 is used to record raw data during acquisition.**
    - **P2/86, P2/91(current), P2/94 (current)**
    - **Must be processed to obtain positions!!**

  - **http://www.oilandgas.org.uk/ukooa/newpublications/srchResults.cfm**

What's a Bursa-Wolf ? Are they endangered ?

- **UKOOA P1/90 – Header records.**
  - There is an extensive and structured set of "H"eader records. Most importantly they define the geodesy of the coordinates.
  - Postplot is what the coordinates are in.

```
H1400GEODETIC DATUM (SURVEY)..: Congo C60    Clarke 1880   6378249.200 293.4660213
H1401TRANSFORMATION TO WGS84..: -178.3-316.7-131.5 5.278 6.07710.97919.1660000
H1500GEODETIC DATUM (POSTPLOT): Congo C60    Clarke 1880   6378249.200 293.4660213
H1501TRANSFORMATION TO WGS84..: -178.3-316.7-131.5 5.278 6.07710.97919.1660000

H1600DATUM TRANSFORMATIONS....:    0.0    0.0    0.0 0.000 0.000 0.000 0.0000000
H1800PROJECTION TYPE .........:  002U.T.M. SOUTHERN HEMISPHERE
H1900PROJECTION ZONE .........: 32 S
H2000GRID UNIT ...............: 1METRES                    01.000000000000
H2001HEIGHT UNIT .............: 1METRES                    01.000000000000
H2002ANGULAR UNIT ............: 1DEGREES
H2200LONG. OF CENTR. MERID. ..:   9 0 0.000E
H2301GRID ORIGIN .............:   0 0 0.000N  9 0 0.000E
H2302GRID COORD. AT ORIGIN ...:   500000.00E10000000.00N
H2401SCALE FACTOR ............: 0.9996000000
H2402LAT/LON WHERE SCALE DEF..:   0 0 0.000N  9 0 0.000E
```

  - The 7-parameter Datum shift model for P1/90 is by definition Bursa-Wolfe (signed for counter-clockwise rotation) so, what does your workstation or application use?

Where's the source!

- ## UKOOA P1/90 – data records
  - **Positions are identified by a prefix ("A"ntenna, "V"essel, "S"ource, "T"ail buoy etc.) They will be in latitude, longitude and in X,Y.**

```
S1511BS02A004    11      5554254220.87S0433253.13W6047923.47114269.02001.8214152621
V1511BS02A004    1       5554254216.57S0433254.67W6047891.17114406.12001.8214152621
T1511BS02A004    1 1     5554254638.16S0433104.73W6050301.97106029.22001.8214152621
```

  - **"R"eceiver or trace number and positions will be in X,Y only.**

```
R    15997781.57118273.3   .0    25997787.97118248.8   .0    35997794.47118224.3   .01
R    45997800.77118199.9   .0    55997807.27118175.4   .0    65997813.57118150.9   .01
R    75997819.97118126.5   .0    85997826.37118102.1   .0    95997832.77118077.6   .01
```

SEG P1 – The format that wouldn't die!

– **SEG - Society of Exploration Geophysicists**

- **SEG "P1" – Position exchange format.**
  - **Considered by our "industry" as the standard for exchange of "Final" land positions.**
  - **Used for almost anything else as well.**
- **Last updated by SEG in 1983.**
- **Supported by most if not all workstations.**
- **80 character "card image" records, blocked 20 is the standard. Rarely blocked, Rarely 80 characters.**
- **Often encoded as EBCDIC rather than ASCII.**
- **Many non-standard versions.**

- **http://seg.org/publications/tech-stand/**

SEG P1 – Pretty normal – incorrect headers

```
     0          10          20          30          40          50          60          70          80
 1 |              POWDER RIVER BASIN, WYOMING SEGP1 FORMAT XY'S
 2
 3  182              101                        578770.05347346.
 4  182              109                        578539.65347195.
 5  182              117                        578303.75347061.
 6  182              125                        578064.65346927.
 7  182              133                        577842.95346821.
 8  182              141                        577616.85346677.
 9  182              149                        577376.45346549.
10  182              157                        577137.15346427.
11  182              165                        576913.65346313.
12  182              173                        576676.05346163.
13  182              181                        576422.05346099.
14  182              189                        576160.05345991.
15  182              197                        575919.75345908.
16  182              205                        575665.75345849.
17  182              213                        575403.25345733.
18  182              221                        575146.05345637.
19  182              229                        574921.25345522.
20  182              237                        574684.85345413.
21  182              245                        574475.55345275.
22  182              253                        574235.35345172.
23  182              261                        573981.65345035.
24  182              269                        573763.75344896.
25  182              277                        573516.05344757.
26  182              285                        573293.45344613.
27  182              293                        573079.05344496.
28  182              301                        572840.55344343.
29  182              309                        572600.05344210.
30  182              317                        572358.15344090.
31  182              325                        572138.05343941.
32  182              333                        571901.15343807.
33  182              341                        571695.55343661.
34  182              349                        571457.75343548.
35  182              357                        571229.15343437.
36  182              365                        571002.85343282.
37  182              373                        570780.65343147.
```

SEG P1 – Headers – Compliant

```
H   SEG-P1 Header

    SEG-P1 Header

    SEG-P1 Header

    SEG-P1 Header

    SEG-P1 Header

    SEG-P1 Header

    SEG-P1 Header

        *

        *

        *
```

These were the actual headers in every file provided for a major mapping project!

- **Headers are often stripped or made compliant to get past the requirement for headers.**

SEG P1 – Unusual – very good headers

```
    0         10        20        30        40        50        60        70        80        90        100
 1 H                        SEISMIC SURVEY DATA
 2 -----------------------------------------------------------------------
 3 PROSPECT      :Wyoming
 4 LINE          :182
 5 FILE NUMBER :Line182.SEG
 6 LINE ID       :
 7 LINE LENGTH :1.118
 8 LENGTH UOM  :MI
 9 RESHOOT CODE:
10 HORIZONTAL DATUM:NAD27, USGS FEET, Degree
11 PROJECTION    :NAD27, Wyoming SPCS, Zone:
12      _1         :There are instances where it
13      _2         :some SP's were assigned the
14      _3         :errors with one only solutio
15      _4         :are needed to determine the
16      _5         :Questionable SP's and corre
17      _6         :QC spreadsheet.
18
19 -----------------------------------------------------------------------
20 <LINE         ><POINT >R< LAT    >< LONG
21 182               101 04493500N1085902
22 182               109 04493451N1085903
23 182               117 04493407N1085904
24 182               125 04493363N1085904
25 182               133 04493328N108590559W  189581 1754203    0
26 182               141 04493281N108590633W  189506 1754156    0
27 182               149 04493239N108590710W  189428 1754114    0
28 182               157 04493199N108590788W  189349 1754074    0
29 182               165 04493161N108590859W  189276 1754036    0
30 182               173 04493112N108590936W  189198 1753987    0
31 182               181 04493090N108591018W  189115 1753966    0
32 182               189 04493055N108591103W  189029 1753931    0
33 182               197 04493027N108591181W  188950 1753903    0
34 182               205 04493008N108591263W  188866 1753884    0
35 182               213 04492970N108591348W  188780 1753846    0
36 182               221 04492937N108591431W  188696 1753814    0
37 182               229 04492900N108591504W  188622 1753777    0
38 182               237 04492864N108591579W  188545 1753741    0
39 182               245 04492819N108591647W  188476 1753696    0
```

– **All these headers are freeform.**

– **Oil companies often create their own standard.**

– **What happens when they exchange data or merge?**

- **SPS - The Shell Processing Support Format for land 3D data.**
  - **Principal format for TZ/OBC.**
  - **Endorsed by both SEG & UKOOA.**
  - **Built in to many newer acquisition systems.**
  - **Has extensive header structure.**
  - **X,Y coordinates only.**
  - **Principal sub files are the "S", "R" and "X".**
  - **The "X" file requires seismic information to construct channel mapping.**

  - **http://seg.org/publications/tech-stand/**

SPS has some commonality with UKOOA

- ## SPS – Header records
  - ### Similar to UKOOA format.

```
H12 Geodetic datum,-spheroid      WGS-84       WGS-84          6378137.000 298.2572236
H14 Geodetic datum parameters       0.000    0.000    0.000 0.000 0.000 0.000 0.000
H17 Vertical datum description  MSL, EQUIPOTENTIAL, 59 34N 01 32E, 47.0m;
H18 Projection type               U.T.M. NORTHERN HEMISPHERE;
H19 Projection zone             31,N;
H20 Description of grid units   METRES;
H201Factor to metre             00001.00000000
H220Long. of central meridian    3 0 0.000E
H231Grid Origin                  0 0 0.000N   3 0 0.000E
H232Grid coord. at origin        500000.00E        0.00N
H241Scale factor                0.9996000000
H242Lat., long. scale factor     0 0 0.000N   3 0 0.000E
```

  - ### 7-parameter shifts are again counter-clockwise Europeans win again!

Channel, ground station, receiver and trace?

- ## **SPS – Data records.**
  - **– "S", "R" and "X".**
  - **– X,Y coordinates only.**

```
S11S0894A289          16771A1        8.0    0    121 422977.2 6609404.2     0.0258065313
S11S0894A289          16752A2        8.0    0    122 422946.1 6609355.5     0.0258065323
S11S0894A289          16731A1        8.0    0    122 422927.1 6609405.9     0.0258065332

R11R0892A001          11561H1        120    0    120 416463.4 6609561.6     0.0257035051
R11R0892A001          11561G1        120    0    120 416463.4 6609561.6     0.0257035051
R11R0892A001          11561G2        120    0    120 416463.4 6609561.6     0.0257035051
R11R0892A001          11561G3        120    0    120 416463.4 6609561.6     0.0257035051

X1     16771111S0894A289             16771    5 204111R0910A001         1554     11561
X1     16771211S0894A289             16771 209 408111R0910A001         1554     11561
X1     16771311S0894A289             16771 413 612111R0910A001         1554     11561
X1     16771411S0894A289             16771 617 816111R0910A001         1554     11561
X1     16771111S0894A289             16771 8211020111R0892A001         1554     11561
X1     16771211S0894A289             1677110251224111R0892A001         1554     11561
X1     16771311S0894A289             1677112291428111R0892A001         1554     11561
X1     16771411S0894A289             1677114331632111R0892A001         1554     11561
```

How come the coordinates changed?

- **Precision of coordinates for seismic.**
  - "**Generally**"
    - Latitude, longitude to 6 decimal places if decimal degrees
    - Latitude, longitude & seconds to 2 decimal places if degrees minutes and seconds
    - X,Y coordinates to 1 or 2 decimal places
  - Most expect meters or feet.
  - The recorded resolution between X,Y and latitude, longitude are not generally equivalent.
    - What came first the Lat,Lon or the X,Y?

How come only the Y coordinates changed!

- **Precision of coordinates for seismic (Cont.).**
  - Some formats were not specified to allow for full precision of all projections and units.
  - You should know about "**implied decimals**".
  - The standard format specifications are defined in FORTRAN nomenclature (FW.D or IW).
    - I8, I10, F8.0, F8.1, F10.2 etc.
      - 12345678 = I8
      - 1234567. = F8.0
      - 12345678 = 1234567.8   if F8.1

DMSH,DMSSS,IMPLIED,SIGNED, UNSIGNED!

```
G965           1435302716.67N 88 1 4.46W1319785.111054512.   11.5190 40318
S1157          1336302341.76N 8758 2.26W 407074.23362764.0    3.9221 45502
R1349          1016 30120536N  87545847W  1351066210962203 54194103170817
R3 D         8371518303017010N 880305980W  1309321 11072824     0152
S1029          1278 30.359719 -88.0006781324907.211019956. 13.10200 01250
```

– All of these records come from the same project.

– There are 4 different formats for Latitude & Longitude.
– There are 5 different formats for X,Y + 1 change of units.
– There are 4 different formats for depth / elevation.
– Two of the records are UKOOA P1/84.
– Two of the records are UKOOA P1/90.
– One was made up in the field.
– Some of them were in the same files.

How good are you with a text editor?

If not, what do your DBF and SHP files look like?

Wonder why they shot it like that, looks like stairs!

– **If you misidentify or
do not understand the precision of coordinates**

Understand Precision and Presentation

Be sure and visit the APSG website and download

Guidance Note for Geodetic and Cartographic Applications (Precision and Presentation)

http://apsg.home.texas.net/

How to solve / understand the issues

- Learn basic Geodesy.
- Realize that Metadata must be retained along with coordinates.
- Exchange data according to accepted standards.
- Understand precision and presentation of coordinates.
- Join or support the APSG and get involved in change.
- Support the EPSG/OGP geodetic database (**www.epsg.org**).

Remember everything is about good positioning!

And applying the right tools & knowledge!

Positioning Issues Related to Seismic Data

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THANK YOU!