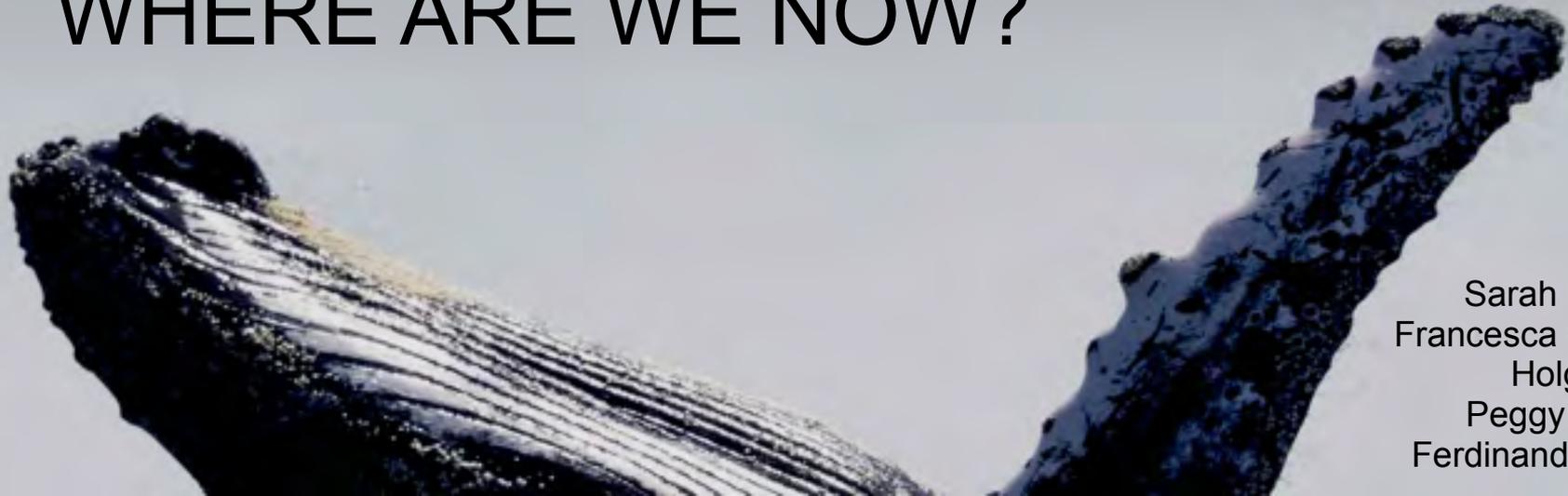


# BIO-LOGGING DATA & STANDARDS

## WHERE ARE WE NOW?



Sarah Davidson  
Francesca Cagnacci  
Holger Dettki  
Peggy Newman  
Ferdinando Urbano

# PREPARING THIS WORKSHOP

---

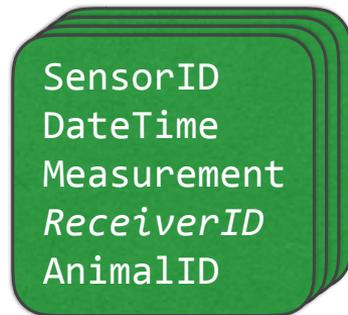
- Organizing committee: 10
- Identified and invited domain experts: ~130
- Survey for bio-logging manufacturers: 42, 24 responses
- Survey for biodiversity data experts: 25, 9 responses
- Compilation of bio-logging database terms: 7 databases

# WHAT ARE “BIO-LOGGING DATA”?

---

At most basic,

- Measurements collected using sensors on animals
- Researcher’s additions to those measurements
- Information about sensors, animals, and deployments



*logged or sent remotely*

*not the 0s and 1s*

# WHY COMPILE BIO-LOGGING DATA?

---

- Integrate a group's **own data**
- **Build and share tools** for data management and analysis
- Meet **institutional, funding and publishing requirements**
- Collaborative research and **meta-analyses**

# WHERE ARE WE NOW?

---

- Many and **diverse sensors** and manufacturers
- Many and **diverse databases** for bio-logging data
- Many and diverse **analysis tools**
- **Resources often restricted** by taxonomy, administrative unit, geography, etc.

*There are lots of good reasons for this! **But...***

# SHARED BIO-LOGGING DATABASES

---



Seabird Tracking Database



seaturtle.org



and many others!

# SHARED TOOLS FOR BIO-LOGGING DATA

---

- adehabitat
- bcpa
- crawl
- ctmm
- Digiroo2
- GeoLight
- mkde
- momentuHMM
- move
- RNCEP
- trip
- tripEstimation



- Animal Movement Analysis (ESRI extension)
- Animal Tracker (mobile app)
- ArcMET (ESRI extension)
- Douglas Argos Filter (SAS, web-based)
- Env-DATA System (web-based)
- Home Range Tools (ESRI extension)
- SOSPROG (MATLAB)
- ZoaTrack Analysis Toolkit (web-based)

**and many others!**

# WHERE ARE WE NOW?

---

*There are lots of good reasons for this! **But...***

- **Inconsistent data** formats, terms, documentation
- Many datasets remain **poorly documented or undiscoverable**
- **Little guidance** for many data users and providers

“the current **lack of standards** for reporting and documenting the data collected by animal-borne telemetry devices is **hampering their effectiveness.**”

Campbell et al. *Anim Biotelemetry* (2016) 4:1  
DOI 10.1186/s40317-015-0096-x

Animal Biotelemetry

COMMENTARY

Open Access



## A plea for standards in reporting data collected by animal-borne electronic devices

Hamish A. Campbell<sup>1\*</sup>, Ferdil Urbano<sup>2</sup>, Sarah Davidson<sup>3</sup>, Holger Dettki<sup>4</sup> and Francesca Cagnacci<sup>5,6</sup>

<http://bit.ly/2fm0QW4>

# NON-STANDARD DATA: AN ILLUSTRATION

- **Seven examples:** identifier and timestamp, values anonymized
- Completed files from research projects and government archives
- None in the original format
- None with documentation
- Common especially for older data
- Context: Import GUI used to map to Movebank database

Data file

Date	Time	Animals_ID
3/21/2006	7:02:00	9
3/21/2006	7:02:00	7
3/21/2006	7:04:00	5
3/21/2006	7:04:00	1
3/21/2006	7:05:00	11
3/21/2006	7:06:00	2

Movebank database

Animal id	Tag id	Timestamp
9	9	2006-03-21 07:02:00.000
7	7	2006-03-21 07:02:00.000
5	5	2006-03-21 07:04:00.000
1	1	2006-03-21 07:04:00.000
11	11	2006-03-21 07:05:00.000
2	2	2006-03-21 07:06:00.000

Edit Attribute Mapping

Movebank attribute:

Verify your Timestamp format and timezone carefully!

Select date/time column(s) Format string

Date

Time

Fixed offset from UTC

Local time zone, e.g. "PST" or "Brazil/East"

Timezone offset:

[Open time zone map](#)

Save Validate Remove Cancel

**ID,LOC\_DATE,LOC\_TIME**

C002A,20-Nov-00,22:15:52

C002A,21-Nov-00,4:15:44

C002A,21-Nov-00,10:15:48

**ID,DateTime,DT**

m\_002,03/08/2003 07:00:24,03/08/2003 07:00:24

m\_002,03/20/2003 01:02:07,03/20/2003 01:02:07

m\_002,03/22/2003 00:01:24,03/22/2003 00:01:24

**birdRing;timestamp**

4182444;2011-12-13T21:42:16+0000

4182444;2011-12-13T22:11:45+0000

4182444;2011-12-13T22:41:59+0000

**Time;**

24/07/2015 12:31;

24/07/2015 12:32;

24/07/2015 12:33;

**Date,Time,Animal\_ID**

3/21/2006,7:02:00,9

3/21/2006,7:02:00,7

3/21/2006,7:04:00,5

**Path\_ID,Date\_Time**

220,21/03/2014 15:35:08

220,21/03/2014 15:39:57

220,21/03/2014 15:45:39

**animal,ptt,date,hour,minute,second,gmt\_date,gmt\_hour,gmt\_min,gmt\_sec**

270,5678,12/21/93,13,40,37,12/21/93,13,40,37

270,5678,12/21/93,16,5,25,12/21/93,16,5,25

270,5678,12/22/93,11,48,57,12/22/93,11,48,57

# FILE TYPE

**Excel**

**ID, LOC\_DATE, LOC\_TIME**

C002A,20-Nov-00,22:15:52

C002A,21-Nov-00,4:15:44

C002A,21-Nov-00,10:15:48

**ID, DateTime, DT**

m\_002,03/08/2003 07:00:24,03/08/2003 07:00:24

m\_002,03/20/2003 01:02:07,03/20/2003 01:02:07

m\_002,03/22/2003 00:01:24,03/22/2003 00:01:24

**birdRing;timestamp**

4182444;2011-12-13T21:42:16+0000

4182444;2011-12-13T22:11:45+0000

4182444;2011-12-13T22:41:59+0000

**Time;**

24/07/2015 12:31;

24/07/2015 12:32;

24/07/2015 12:33;

**Date,Time,Animal\_ID**

3/21/2006,7:02:00,9

3/21/2006,7:02:00,7

3/21/2006,7:04:00,5

**Path\_ID,Date\_Time**

220,21/03/2014 15:35:08

220,21/03/2014 15:39:57

220,21/03/2014 15:45:39

**animal,ptt,date,hour,minute,second,gmt\_date,gmt\_hour,gmt\_min,gmt\_sec**

270,5678,12/21/93,13,40,37,12/21/93,13,40,37

270,5678,12/21/93,16,5,25,12/21/93,16,5,25

270,5678,12/22/93,11,48,57,12/22/93,11,48,57

# FILE TYPE

**comma-delimited text**

**ID, LOC\_DATE, LOC\_TIME**

C002A, 20-Nov-00, 22:15:52

C002A, 21-Nov-00, 4:15:44

C002A, 21-Nov-00, 10:15:48

**ID, DateTime, DT**

m\_002, 03/08/2003 07:00:24, 03/08/2003 07:00:24

m\_002, 03/20/2003 01:02:07, 03/20/2003 01:02:07

m\_002, 03/22/2003 00:01:24, 03/22/2003 00:01:24

**birdRing; timestamp**

4182444; 2011-12-13T21:42:16+0000

4182444; 2011-12-13T22:11:45+0000

4182444; 2011-12-13T22:41:59+0000

**Time;**

24/07/2015 12:31;

24/07/2015 12:32;

24/07/2015 12:33;

**Date, Time, Animal\_ID**

3/21/2006, 7:02:00, 9

3/21/2006, 7:02:00, 7

3/21/2006, 7:04:00, 5

**Path\_ID, Date\_Time**

220, 21/03/2014 15:35:08

220, 21/03/2014 15:39:57

220, 21/03/2014 15:45:39

**animal, ptt, date, hour, minute, second, gmt\_date, gmt\_hour, gmt\_min, gmt\_sec**

270, 5678, 12/21/93, 13, 40, 37, 12/21/93, 13, 40, 37

270, 5678, 12/21/93, 16, 5, 25, 12/21/93, 16, 5, 25

270, 5678, 12/22/93, 11, 48, 57, 12/22/93, 11, 48, 57

# FILE TYPE

**semicolon-delimited text**

**ID, LOC\_DATE, LOC\_TIME**

C002A, 20-Nov-00, 22:15:52

C002A, 21-Nov-00, 4:15:44

C002A, 21-Nov-00, 10:15:48

**ID, DateTime, DT**

m\_002, 03/08/2003 07:00:24, 03/08/2003 07:00:24

m\_002, 03/20/2003 01:02:07, 03/20/2003 01:02:07

m\_002, 03/22/2003 00:01:24, 03/22/2003 00:01:24

**birdRing; timestamp**

4182444; 2011-12-13T21:42:16+0000

4182444; 2011-12-13T22:11:45+0000

4182444; 2011-12-13T22:41:59+0000

**Time;**

24/07/2015 12:31;

24/07/2015 12:32;

24/07/2015 12:33;

**Date, Time, Animal\_ID**

3/21/2006, 7:02:00, 9

3/21/2006, 7:02:00, 7

3/21/2006, 7:04:00, 5

**Path\_ID, Date\_Time**

220, 21/03/2014 15:35:08

220, 21/03/2014 15:39:57

220, 21/03/2014 15:45:39

**animal, ptt, date, hour, minute, second, gmt\_date, gmt\_hour, gmt\_min, gmt\_sec**

270, 5678, 12/21/93, 13, 40, 37, 12/21/93, 13, 40, 37

270, 5678, 12/21/93, 16, 5, 25, 12/21/93, 16, 5, 25

270, 5678, 12/22/93, 11, 48, 57, 12/22/93, 11, 48, 57

# IDENTIFIERS

## 7 unique terms

ID

birdRing

Animal\_ID

Path\_ID

animal, ptt

none (in filename)

# IDENTIFIERS

```
ID,LOC_DATE,LOC_TIME  
C002A,20-Nov-00,22:15:52  
C002A,21-Nov-00,4:15:44  
C002A,21-Nov-00,10:15:48
```

```
ID,DateTime,DT  
m_002,03/08/2003 07:00:24,03/08/2003 07:00:24  
m_002,03/20/2003 01:02:07,03/20/2003 01:02:07  
m_002,03/22/2003 00:01:24,03/22/2003 00:01:24
```

```
birdRing;timestamp  
4182444;2011-12-13T21:42:16+0000  
4182444;2011-12-13T22:11:45+0000  
4182444;2011-12-13T22:41:59+0000
```

```
Time;  
24/07/2015 12:31;  
24/07/2015 12:32;  
24/07/2015 12:33;
```

**sensor, animal, deployment, or segment?**

```
Date,Time,Animal_ID  
3/21/2006,7:02:00,9  
3/21/2006,7:02:00,7  
3/21/2006,7:04:00,5
```

```
Path_ID,Date_Time  
220,21/03/2014 15:35:08  
220,21/03/2014 15:39:57  
220,21/03/2014 15:45:39
```

```
animal,ptt,date,hour,minute,second,gmt_date,gmt_hour,gmt_min,gmt_sec  
270,5678,12/21/93,13,40,37,12/21/93,13,40,37  
270,5678,12/21/93,16,5,25,12/21/93,16,5,25  
270,5678,12/22/93,11,48,57,12/22/93,11,48,57
```

# IDENTIFIERS

ID, LOC\_DATE, LOC\_TIME

C002A, 20-Nov-00, 22:15:52

C002A, 21-Nov-00, 4:15:44

C002A, 21-Nov-00, 10:15:48

ID, DateTime, DT

m\_002, 03/08/2003 07:00:24, 03/08/2003 07:00:24

m\_002, 03/20/2003 01:02:07, 03/20/2003 01:02:07

m\_002, 03/22/2003 00:01:24, 03/22/2003 00:01:24

birdRing; timestamp

4182444; 2011-12-13T21:42:16+0000

4182444; 2011-12-13T22:11:45+0000

4182444; 2011-12-13T22:41:59+0000

Time;

24/07/2015 12:31;

24/07/2015 12:32;

24/07/2015 12:33;

**sensor, animal, deployment, or segment?**

Date, Time, Animal\_ID

3/21/2006, 7:02:00, 9

3/21/2006, 7:02:00, 7

3/21/2006, 7:04:00, 5

**relation to sensor id?**

Path\_ID, Date\_Time

220, 21/03/2014 15:35:08

220, 21/03/2014 15:39:57

220, 21/03/2014 15:45:39

**animal, ptt, date, hour, minute, second, gmt\_date, gmt\_hour, gmt\_min, gmt\_sec**

270, 5678, 12/21/93, 13, 40, 37, 12/21/93, 13, 40, 37

270, 5678, 12/21/93, 16, 5, 25, 12/21/93, 16, 5, 25

270, 5678, 12/22/93, 11, 48, 57, 12/22/93, 11, 48, 57

**ID, LOC\_DATE, LOC\_TIME**

C002A, 20-Nov-00, 22:15:52

C002A, 21-Nov-00, 4:15:44

C002A, 21-Nov-00, 10:15:48

**ID, DateTime, DT**

m\_002, 03/08/2003 07:00:24, 03/08/2003 07:00:24

m\_002, 03/20/2003 01:02:07, 03/20/2003 01:02:07

m\_002, 03/22/2003 00:01:24, 03/22/2003 00:01:24

**birdRing; timestamp**

4182444; 2011-12-13T21:42:16+0000

4182444; 2011-12-13T22:11:45+0000

4182444; 2011-12-13T22:41:59+0000

**Time;**

24/07/2015 12:31;

24/07/2015 12:32;

24/07/2015 12:33;

**Date, Time, Animal\_ID**

3/21/2006, 7:02:00, 9

3/21/2006, 7:02:00, 7

3/21/2006, 7:04:00, 5

**Path\_ID, Date\_Time**

220, 21/03/2014 15:35:08

220, 21/03/2014 15:39:57

220, 21/03/2014 15:45:39

**animal, ptt, date, hour, minute, second, gmt\_date, gmt\_hour, gmt\_min, gmt\_sec**

270, 5678, 12/21/93, 13, 40, 37, 12/21/93, 13, 40, 37

270, 5678, 12/21/93, 16, 5, 25, 12/21/93, 16, 5, 25

270, 5678, 12/22/93, 11, 48, 57, 12/22/93, 11, 48, 57

# DATES AND TIMES

## 7 unique date-time terms

LOC\_DATE, LOC\_TIME

DateTime, DT

timestamp

Time

Date, Time

Date\_Time

date, hour, minute, second, etc.

**ID, LOC\_DATE, LOC\_TIME**

C002A, 20-Nov-00, 22:15:52

C002A, 21-Nov-00, 4:15:44

C002A, 21-Nov-00, 10:15:48

**ID, DateTime, DT**

m\_002, 03/08/2003 07:00:24, 03/08/2003 07:00:24

m\_002, 03/20/2003 01:02:07, 03/20/2003 01:02:07

m\_002, 03/22/2003 00:01:24, 03/22/2003 00:01:24

**birdRing; timestamp**

4182444; 2011-12-13T21:42:16+0000

4182444; 2011-12-13T22:11:45+0000

4182444; 2011-12-13T22:41:59+0000

**Time;**

24/07/2015 12:31;

24/07/2015 12:32;

24/07/2015 12:33;

**Date, Time, Animal\_ID**

3/21/2006, 7:02:00, 9

3/21/2006, 7:02:00, 7

3/21/2006, 7:04:00, 5

**Path\_ID, Date\_Time**

220, 21/03/2014 15:35:08

220, 21/03/2014 15:39:57

220, 21/03/2014 15:45:39

**animal, ptt, date, hour, minute, second, gmt\_date, gmt\_hour, gmt\_min, gmt\_sec**

270, 5678, 12/21/93, 13, 40, 37, 12/21/93, 13, 40, 37

270, 5678, 12/21/93, 16, 5, 25, 12/21/93, 16, 5, 25

270, 5678, 12/22/93, 11, 48, 57, 12/22/93, 11, 48, 57

# DATES AND TIMES

## 7 unique date-time formats

dd-MMM-yy, HH:mm:ss

MM/dd/yyyy HH:mm:ss

yyyy-??-??THH:mm:ss+offset

dd/MM/yyyy HH:mm

M/dd/yyyy, HH:mm:ss

dd/MM/yyyy HH:mm:ss

MM/dd/yy, HH, mm, ss

# DATES AND TIMES

**ID, LOC\_DATE, LOC\_TIME**

C002A, 20-Nov-00, 22:15:52

C002A, 21-Nov-00, 4:15:44

C002A, 21-Nov-00, 10:15:48

**ID, DateTime, DT**

m\_002, 03/08/2003 07:00:24, 03/08/2003 07:00:24

m\_002, 03/20/2003 01:02:07, 03/20/2003 01:02:07

m\_002, 03/22/2003 00:01:24, 03/22/2003 00:01:24

**birdRing; timestamp**

4182444; 2011-12-13T21:42:16+0000

4182444; 2011-12-13T22:11:45+0000

4182444; 2011-12-13T22:41:59+0000

**Time;**

24/07/2015 12:31;

24/07/2015 12:32;

24/07/2015 12:33;

**timezone or UTC offset usually not provided**

**Date, Time, Animal\_ID**

3/21/2006, 7:02:00, 9

3/21/2006, 7:02:00, 7

3/21/2006, 7:04:00, 5

**months vs days often difficult to guess**

**Path\_ID, Date\_Time**

220, 21/03/2014 15:35:08

220, 21/03/2014 15:39:57

220, 21/03/2014 15:45:39

**animal, ptt, date, hour, minute, second, gmt\_date, gmt\_hour, gmt\_min, gmt\_sec**

270, 5678, 12/21/93, 13, 40, 37, 12/21/93, 13, 40, 37

270, 5678, 12/21/93, 16, 5, 25, 12/21/93, 16, 5, 25

270, 5678, 12/22/93, 11, 48, 57, 12/22/93, 11, 48, 57

**ID, LOC\_DATE, LOC\_TIME**

C002A, 20-Nov-00, 22:15:52

C002A, 21-Nov-00, 4:15:44

C002A, 21-Nov-00, 10:15:48

**ID, DateTime, DT**

m\_002, 03/08/2003 07:00:24, 03/08/2003 07:00:24

m\_002, 03/20/2003 01:02:07, 03/20/2003 01:02:07

m\_002, 03/22/2003 00:01:24, 03/22/2003 00:01:24

**birdRing; timestamp**

4182444; 2011-12-13T21:42:16+0000

4182444; 2011-12-13T22:11:45+0000

4182444; 2011-12-13T22:41:59+0000

**Time;**

24/07/2015 12:31;

24/07/2015 12:32;

24/07/2015 12:33;

**Date, Time, Animal\_ID**

3/21/2006, 7:02:00, 9

3/21/2006, 7:02:00, 7

3/21/2006, 7:04:00, 5

**Path\_ID, Date\_Time**

220, 21/03/2014 15:35:08

220, 21/03/2014 15:39:57

220, 21/03/2014 15:45:39

**animal, ptt, date, hour, minute, second, gmt\_date, gmt\_hour, gmt\_min, gmt\_sec**

270, 5678, 12/21/93, 13, 40, 37, 12/21/93, 13, 40, 37

270, 5678, 12/21/93, 16, 5, 25, 12/21/93, 16, 5, 25

270, 5678, 12/22/93, 11, 48, 57, 12/22/93, 11, 48, 57

# DATES AND TIMES

redundant values/terms?

```
ID,LOC_DATE,  
C002A,20-Nov-00,  
C002A,21-Nov-00,  
C002A,21-Nov-00,
```

```
ID,DateTime,DT  
m_002,03/08/2003 07:00:24,03/08/2003 07:00:24  
m_002,03/20/2003 01:02:07,03/20/2003 01:02:07  
m_002,03/22/2003 00:01:24,03/22/2003 00:01:24
```

```
birdRing;timestamp  
4182444;2011-12-13T21:42:16+0000  
4182444;2011-12-13T22:11:45+0000  
4182444;2011-12-13T22:41:50+0000
```

```
Time;Location;Time;Location;  
24/07/2015 12:31; 24/07/2015 12:32;  
24/07/2015 12:33;
```

```
Date,Time,Animal_ID  
3/21/2006,7:02:00,9  
3/21/2006,7:02:00,7  
3/21/2006,7:04:00,5
```

```
Path_ID,Date_Time  
220,21/03/2014 15:35:08  
220,21/03/2014 15:39:57  
220,21/03/2014 15:45:39
```

```
animal,ptt,date,hour,minute,second,gmt_date,gmt_hour,gmt_min,gmt_sec  
270,5678,12/21/93,13,40,37,12/21/93,13,40,37  
270,5678,12/21/93,16,5,25,12/21/93,16,5,25  
270,5678,12/22/93,11,48,57,12/22/93,11,48,57
```

# Boring, right?!

# BENEFITS OF STANDARDS

---

- **Less time needed** to collect and integrate datasets
- **Reduced error** and uncertainty
- More **collaborations** and re-use
- Increased accessibility and reduced support needs for **shared tools**
- Enabled **conservation efforts, media coverage** and **outreach**
- Increased **discoverability** for other researchers and public
- Standardized and well-documented **archiving**

# BIODIVERSITY DATA RESOURCES

---



Ecological Metadata Language (EML)

Darwin Core



# CHALLENGES

---

- **Support existing diversity** in sensors, manufacturers, information collected, workflow, databases, initiatives
- Offer resources available to the **entire bio-logging community**
- Accommodate **existing data**
- Allow for active and inclusive **development and outreach**

# POSSIBLE TYPES OF STANDARDS

---

- Format/protocol to send sensor info and decoded sensor data to users
- Data terms, vocabularies, thesauri
- Shared archive/export format
- Best practices for making bio-logging datasets widely discoverable