Data management and archival with APECS

02 Nov 2018; Tiff Stephens

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1. Introduction

Great work in collecting mountains of data! The next step is to make sure that we are all on the same page with how these data (and metadata) are handled so that they are accessible to other APECS members, as well prepped appropriately for long-term storage via archival. This document provides a guideline for how APECS preps data files for storage and analysis to help ensure that we meet the goals of our management plan. Each of you will help APECS reach such goals via curating the data that you collected and working with Tiff to eventually archive it.

First, you should be aware that both grants under the APECS umbrella have a data management plan. They are not complex but serve as a promise to ourselves and to NSF that we will be responsible with the expensive data that we were funded to collect. The plans outline:

- That we will be compliant with NSF data management and dissemination policies (essentially: don't lose data, keep it clean, and make it available to others).
- That all data is secure during the project (e.g. backed-up).
- That all datasets will be accompanied by appropriate metadata.
- That all data will be submitted to appropriate data repositories no later than two years after being collected. Eventually all should be publicly available.
- That we will submit data in an accessible and flexible format (i.e. .csv files).

A summary of steps required to meet our data management goals

- Make sure that entered data are accurate and that they the dataset is in a "clean" format.
- Have a Masterfile for each dataset that will not be manipulated.
- Make sure that each dataset has appropriate metadata.
- Store datasets in locations accessible to all APECS members (i.e. shared Google Drive and GitHub)
- Work with Tiff to archive data with selected repositories (i.e. KNB and BCO-DMO)

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2. Enter raw data and turn it into a clean and defined dataset

Enter data

After fieldwork, labwork, etc., raw data need to be collated into a spreadsheet. To save time, be mindful of how those data are organized in a working dataset before entering data. For example, you don't want to have to go through and copy + paste things into different columns later (*note: regardless of time, this isn't recommended because it often results in human-induced errors within the dataset*). Tiff likes to enter everything into as few of columns as possible (e.g. multiple levels included in one column/factor) and then use R functions to manipulate the structure of the dataframe later. Datasets should be "clean", which, convenient for some, aligns with structure appropriate for analysis in R.

What is a clean dataset? Essentially, each variable (dependent and independent) should have its own column, where the rows in each column includes a single point of information. Columns can have multiple levels included to help characterize single datapoints across rows – for example a "sea_otter_region" column can have "high", "mid", and "low" factors within them.

Some fundamental guidelines for structuring a dataset are described below, paired with Fig 1:

A. Text in column titles and in rows: Some statistical packages do not like spaces or slashes in column titles. Instead use an underscore or period between words/characters. Typically, spaces in rows below each column title is just fine.

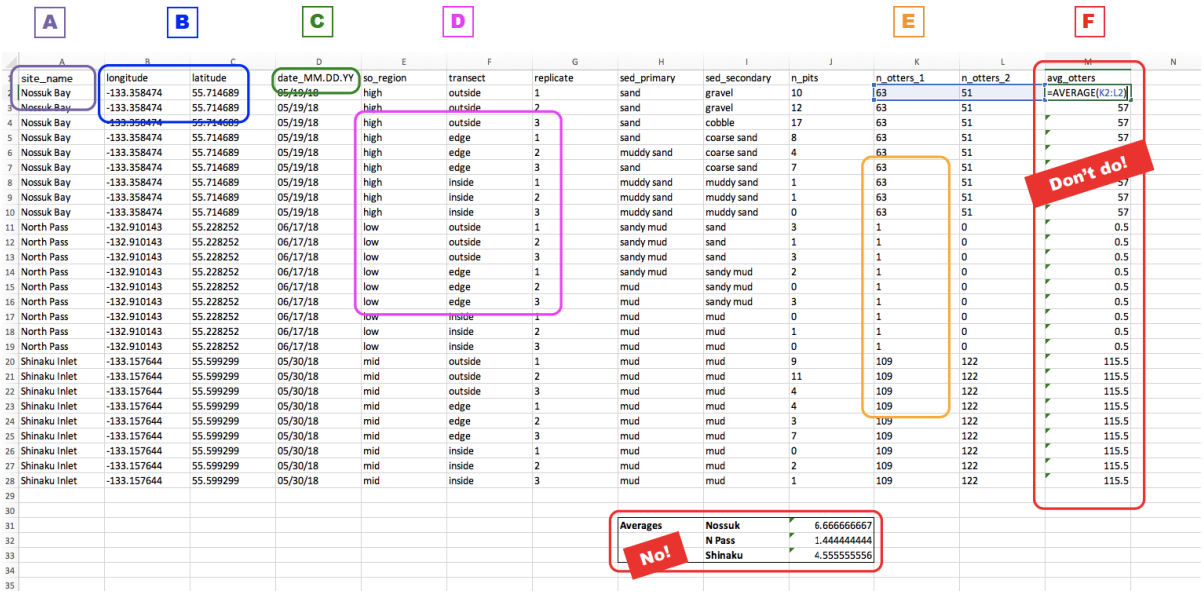
B. It's easiest, and more universal, to keep latitudes and longitudes in decimal degrees. Make sure that this is defined in the column title and/or the metadata.

C. For dates, please annotate what format your data are in, especially in the metadata but it is also useful for column titles. e.g. "date_MM.DD.YY", "date_YYYY.MM.DD". Date data are notorious troublemakers in both analysis and archival, especially for international access.

D. These columns are examples of how multiple levels can be included in one factor (column). Notice how the information is nested, i.e. that each replicate is nested within its respective transect, nested within the respective site. Depending on your preference, these different levels can occupy separate columns (like shown with the density data in columns K and L).

E. Note that if there are site-level data, such needs to be filled in for EVERY unique datapoint.

F. Two issues here: (1) running calculations in Excel and (2) saving files with calculation sections or seemingly random boxes of data/information (see bottommost rows). Unless you're running data analysis in Excel (please don't do this), there should be no calculations saved in the spreadsheet. If you're using R for analysis, please avoid calculating *anything* in Excel, even simple sums or means. . . mistakes will happen. In this example, it is better to leave the two density columns as raw and calculate their means using code in R because it is reproducible and more reliable. The second issue will be misinterpretted by your statistical software; whatever platform you use incorporates information from the entire column called upon and thus would include "Averages", "Nossuk", "N Pass", and "Shinaku" as levels in the sediment columns, and the associated mean values as new datapoints in the pits column. Just don't do these things.



site_name	longitude	latitude	date_MM.DD.YY	so_region	transect	replicate	sed_primary	sed_secondary	n_pits	n_otters_1	n_otters_2	avg_otters
Nossuk Bay	-133.358474	55.714689	05/19/18	high	outside	1	sand	gravel	10	63	51	=AVERAGE(K2:L2)
Nossuk Bay	-133.358474	55.714689	05/19/18	high	outside	2	sand	gravel	12	63	51	57
Nossuk Bay	-133.358474	55.714689	05/19/18	high	outside	3	sand	cobble	17	63	51	57
Nossuk Bay	-133.358474	55.714689	05/19/18	high	edge	1	sand	coarse sand	8	63	51	57
Nossuk Bay	-133.358474	55.714689	05/19/18	high	edge	2	muddy sand	coarse sand	4	63	51	
Nossuk Bay	-133.358474	55.714689	05/19/18	high	edge	3	sand	coarse sand	7	63	51	
Nossuk Bay	-133.358474	55.714689	05/19/18	high	inside	1	muddy sand	muddy sand	1	63	51	57
Nossuk Bay	-133.358474	55.714689	05/19/18	high	inside	2	muddy sand	muddy sand	1	63	51	57
Nossuk Bay	-133.358474	55.714689	05/19/18	high	inside	3	muddy sand	muddy sand	0	63	51	57
North Pass	-132.910143	55.228252	06/17/18	low	outside	1	sandy mud	sand	3	1	0	0.5
North Pass	-132.910143	55.228252	06/17/18	low	outside	2	sandy mud	sand	1	1	0	0.5
North Pass	-132.910143	55.228252	06/17/18	low	outside	3	sandy mud	sand	3	1	0	0.5
North Pass	-132.910143	55.228252	06/17/18	low	edge	1	sandy mud	sandy mud	2	1	0	0.5
North Pass	-132.910143	55.228252	06/17/18	low	edge	2	mud	sandy mud	0	1	0	0.5
North Pass	-132.910143	55.228252	06/17/18	low	edge	3	mud	sandy mud	3	1	0	0.5
North Pass	-132.910143	55.228252	06/17/18	low	inside	1	mud	mud	0	1	0	0.5
North Pass	-132.910143	55.228252	06/17/18	low	inside	2	mud	mud	1	1	0	0.5
North Pass	-132.910143	55.228252	06/17/18	low	inside	3	mud	mud	0	1	0	0.5
Shinaku Inlet	-133.157644	55.599299	05/30/18	mid	outside	1	mud	mud	9	109	122	115.5
Shinaku Inlet	-133.157644	55.599299	05/30/18	mid	outside	2	mud	mud	11	109	122	115.5
Shinaku Inlet	-133.157644	55.599299	05/30/18	mid	outside	3	mud	mud	4	109	122	115.5
Shinaku Inlet	-133.157644	55.599299	05/30/18	mid	edge	1	mud	mud	4	109	122	115.5
Shinaku Inlet	-133.157644	55.599299	05/30/18	mid	edge	2	mud	mud	3	109	122	115.5
Shinaku Inlet	-133.157644	55.599299	05/30/18	mid	edge	3	mud	mud	7	109	122	115.5
Shinaku Inlet	-133.157644	55.599299	05/30/18	mid	inside	1	mud	mud	0	109	122	115.5
Shinaku Inlet	-133.157644	55.599299	05/30/18	mid	inside	2	mud	mud	2	109	122	115.5
Shinaku Inlet	-133.157644	55.599299	05/30/18	mid	inside	3	mud	mud	1	109	122	115.5

Averages	Nossuk	6.666666667
	N Pass	1.444444444
	Shinaku	4.555555556

Figure 1 Example dataset used as an example for the guidelines listed above.

Don't forget to QC/QA.

It's necessary to check ALL of the entered data with assure that it is accurate; hopefully it goes faster than the initial entry. Even after verifying everything, some like to review the dataset in R to see if there are any odd entries or values that don't make sense before fully accepting that the QC/QA process is complete. There are *a lot* of different ways to check data (many opinions and strategies outlined on the web) but it is good practice to (1) at least determine that functions like "summary()" work without incurring errors and (2) manually sort each column in the dataframe to check for obvious errors (e.g. odd placement of "NA" or accidental character inclusion, like an "." instead of "0" or "NA").

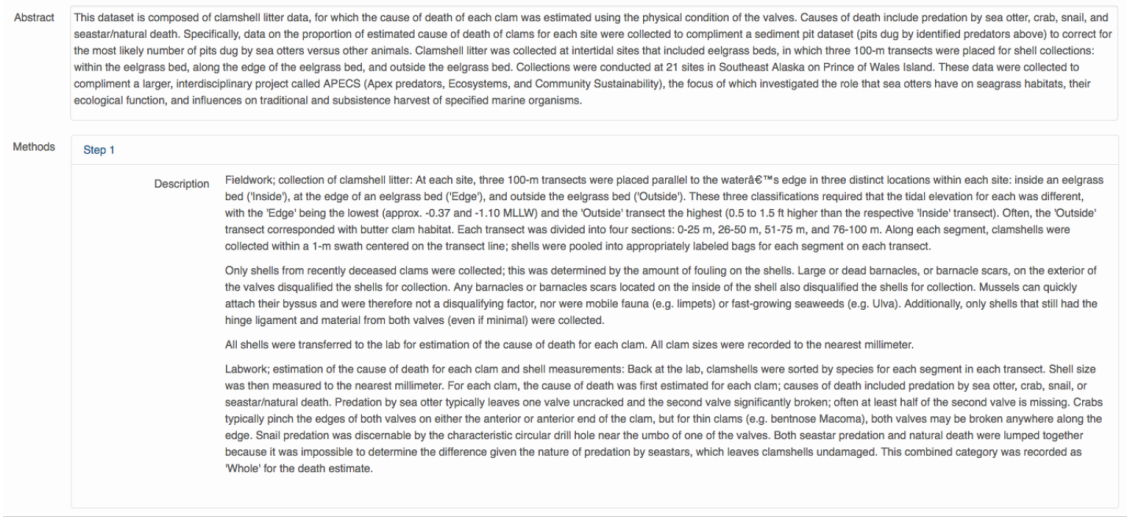
Metadata!

It is absolutely critical to build descriptive metadata for each dataset. What do I mean by metadata?:

- **Short, direct definitions**: This often involves transposing the column titles used in the dataset and providing an informative definition of each factor in your datasheet (example below). This can be saved as a seperate tab in an Excel document but will ultimately need to be a separate .csv file to pair with your data for archival.

Factor	Description
site_name	Identifying name of the field site
longitude	Longitude (E) of the site in decimal degrees
latitude	Latitude (N) of the site in decimal degrees
date_MM.DD.YY	Date of sampling expressed as month, day, and year (MM/DD/YY)
so_region	Regional categorization of sea otter presence; 3 levels: high, mid, low
transect	Transect location within each site relative to the seagrass bed
sed_primary	Qualitative characterization of primary sediment type (e.g. sand, mud)
n_pits	Number of pits counted within the transect replicate
n_otters	Number of sea otters counted in the boat survey

- **Brief summary**: This should include information about the purpose of the dataset and basic summary of where and how it was collected. Think "briefer version of the methods section". This is an extremely valuable description for people that will access the publicly available data years down the road, it can be the clencher for whether your data are usable/interpretable by future parties. This is a requirement for submitting to data repositories, a real-life KNB example shown below:



Abstract

This dataset is composed of clamshell litter data, for which the cause of death of each clam was estimated using the physical condition of the valves. Causes of death include predation by sea otter, crab, snail, and seastar/natural death. Specifically, data on the proportion of estimated cause of death of clams for each site were collected to compliment a sediment pit dataset (pits dug by identified predators above) to correct for the most likely number of pits dug by sea otters versus other animals. Clamshell litter was collected at intertidal sites that included eelgrass beds, in which three 100-m transects were placed for shell collections: within the eelgrass bed, along the edge of the eelgrass bed, and outside the eelgrass bed. Collections were conducted at 21 sites in Southeast Alaska on Prince of Wales Island. These data were collected to compliment a larger, interdisciplinary project called APECS (Apex predators, Ecosystems, and Community Sustainability), the focus of which investigated the role that sea otters have on seagrass habitats, their ecological function, and influences on traditional and subsistence harvest of specified marine organisms.

Methods

Step 1

Description

Fieldwork; collection of clamshell litter: At each site, three 100-m transects were placed parallel to the waterâ€™s edge in three distinct locations within each site: inside an eelgrass bed ('Inside'), at the edge of an eelgrass bed ('Edge'), and outside the eelgrass bed ('Outside'). These three classifications required that the tidal elevation for each was different, with the 'Edge' being the lowest (approx. -0.37 and -1.10 MLLW) and the 'Outside' transect the highest (0.5 to 1.5 ft higher than the respective 'Inside' transect). Often, the 'Outside' transect corresponded with butter clam habitat. Each transect was divided into four sections: 0-25 m, 26-50 m, 51-75 m, and 76-100 m. Along each segment, clamshells were collected within a 1-m swath centered on the transect line; shells were pooled into appropriately labeled bags for each segment on each transect.

Only shells from recently deceased clams were collected; this was determined by the amount of fouling on the shells. Large or dead barnacles, or barnacle scars, on the exterior of the valves disqualified the shells for collection. Any barnacles or barnacles scars located on the inside of the shell also disqualified the shells for collection. Mussels can quickly attach their byssus and were therefore not a disqualifying factor, nor were mobile fauna (e.g. limpets) or fast-growing seaweeds (e.g. Ulva). Additionally, only shells that still had the hinge ligament and material from both valves (even if minimal) were collected.

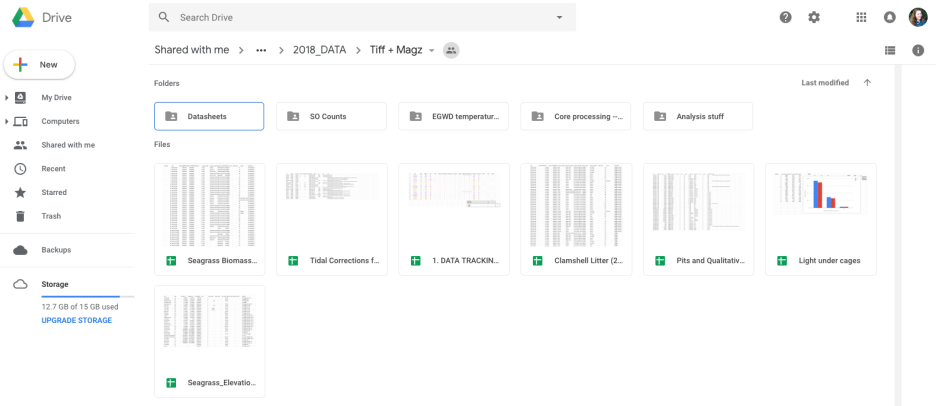
All shells were transferred to the lab for estimation of the cause of death for each clam. All clam sizes were recorded to the nearest millimeter.

Labwork; estimation of the cause of death for each clam and shell measurements: Back at the lab, clamshells were sorted by species for each segment in each transect. Shell size was then measured to the nearest millimeter. For each clam, the cause of death was first estimated for each clam; causes of death included predation by sea otter, crab, snail, or seastar/natural death. Predation by sea otter typically leaves one valve uncracked and the second valve significantly broken; often at least half of the second valve is missing. Crabs typically pinch the edges of both valves on either the anterior or anterior end of the clam, but for thin clams (e.g. bentnose Macoma), both valves may be broken anywhere along the edge. Snail predation was discernable by the characteristic circular drill hole near the umbo of one of the valves. Both seastar predation and natural death were lumped together because it was impossible to determine the difference given the nature of predation by seastars, which leaves clamshells undamaged. This combined category was recorded as 'Whole' for the death estimate.

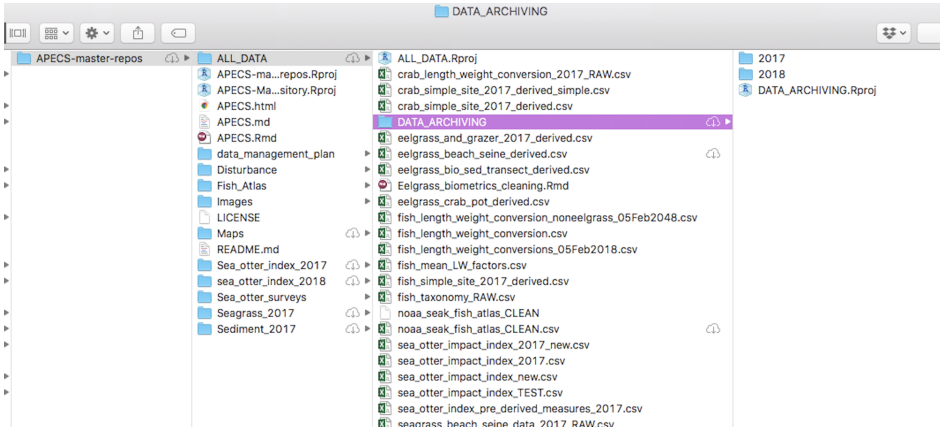
3. Day-to-day storage of data

The two most important things to do remember when storing data are (1) to not lose the data and (2) to keep a **Masterfile** of each datasheet (after QC/QA) that will not be manipulated. There are two places that APECS stores data so that it is safe and accessible by APECS members: the shared Google Drive and GitHub platforms that APECS curates. Backing-up data on personal/lab hard drives and computers is also approprate (if not inevitable). Keep in mind, however, that it is important to be weary and conscious of multiple file versions. In the end, APECS *really* only wants two versions of each datasheet for APECS-related storage and analysis – ** RAW and CLEAN versions** – storing data and knowing which version to use for analysis can get messy if you have 20 different versions of the same file.

- **Google Drive**: I think that we're all familiar with this, already, since many have their own folder within the data folder in the shared drive. If you don't have one, please start one, and if you don't have access, please ask me for it. It's fine to leave these files as google files (as opposed to .csv), but it is important to have obvious names for each file, noting whether it is raw or clean.



- **GitHub**: Tiff and Wendel have been working from the APECS GitHub folder, meaning that in addition to storage in the Google Drive, we store datasets in the "APECS-master-repos" folder to call upon in RStudio (or R) for data manipulation and analysis. We held a workshop on this last year but since few people had datasets to practice with, it is 100% understandable and recomended to consult with either Tiff or Wendel if you want to get in on the GitHub stoke. As a reminder, you'll want to have a local GitHub folder system on your local computer that links to the online GitHub repository.



4. Long-term archival of data

Generally, you will work with Tiff to successfully upload all APECS-collected data into preferred data repositories. In APECS' data management plans with NSF, we committed to archiving all data with BCO-DMO (Biological and Chemical Oceanography Data Management Office) but are also submitting to KNB (Knowledge Network for Biocomplexity). The latter is more user friendly and the archived data is accessible to BCO-DMO.

The important prep information for data archival was largely covered in the section about data structure and metadata – i.e. your data need to be in shape so that anyone can interpret and use them. The archival process involve the following files:

- Dataset that is cleaned (required)
- Metadata (required)
- Raw dataset (recommended but optional; great for reproducibility)
- Code used to transform raw data into working data (recommended but optional; great for reproducibility)
- Diagram to help convey methods for data collection (optional)

There isn't much more to say here other than archival is a serious business and it's best to be thorough because you don't know who will access your dataset, what they'll use it for, and whether you'll still be alive if they have questions. You can look at an example from last year, where Tiff archived 2017 data using a series of submissions to KNB (https://knb.ecoinformatics.org/view/knb.92121.19). *Note: KNB has been updating their user platform a lot, recently, so even Tiff needs to give it a new browse to make sure that functionality is as she knows it.*