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Oceanographic In-situ data Interoperability Project

NETCDF TEMPLATES FOR ELECTRONIC TAG DATA

nc-eTAG Specification

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Contributors

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1 Overview

OIIP (Oceanographic In-situ data Interoperability Project) is a NASA/ACCESS technology development project that seeks to extend available (higher TRL) technologies, including the NCEI netCDF in-situ data templates, to address key interoperability and data challenges associated with oceanographic *in situ* datasets, focusing on marine animal electronic tagging data as a representative (but also more challenging) use case. Previous documentation produced by the OIIP project and published online has reviewed the applicability of the NCEI netCDF template to support the suite of (non-acoustic) electronic data from the range of tag manufacturers [1]. We have also proposed extensions, based on expert tagging community input, enabling support for richer sets of domain specific metadata for inclusion in such self-describing electronic tagging data files [2]. The latter, which is important in that it embeds the necessary information necessary for the correct interpretation, science utilization and long-term preservation of the instrument data, includes a specification for the packaging of such rich metadata consistent with the latest Earth Science data interoperability standards and next generation CF enhancements [3]. This approach has already been successfully applied in the context of satellite missions such as NASA-SMAP.

Here we take the next step, and provide detailed technical specifications on how the range of key tagging data class types - satellite positional, archival and retrieved popup satellite archival (PSAT) trajectory series, and PSAT transmitted summary data - can be encoded consistent with the aforementioned standards. This is important because it provides a practical roadmap that will bring tagging data into direct alignment with a common data interoperability framework being used for ocean observations ranging from satellite and remotely sensed airborne observations to measurements from diverse in-situ platforms. The latter includes gliders and other such instrument platforms that share similar spatial geometry sampling characteristics as tagged animals serving as biological platforms. The future successful inclusion of animal telemetry data as new and valuable element of this integrated ocean observing system in support of a whole suite of applications will hinge critically upon the adoption of these common data interoperability standards for the production of archive quality instrument data files from electronic tag deployments on animal observational platforms. There are naturally nuances to the animal telemetry data which that have required some extensions, both to provide support for both the breadth of metadata desired for inclusion in self-describing data file formats and the particularities of electronic tagging instrument data representations. All of these needs have been accounted for comprehensively, and the outcome is the netCDF electronic tag template (nc-eTAG) specifications presented in this document.

The three detailed netCDF CDL (Common Data Language) [4] templates for (non-acoustic) animal telemetry data documented here provide the necessary roadmap and set of data engineering specifications to encode and produce interoperable instrument data files for the aforementioned three classes of electronic tagging data types. The nc-eTAG templates will serve as a valuable resource for data producers, data assembly centers, data archives, and electronic tag instrument manufacturers wanting to implement archive quality, interoperable data files consistent with current Earth Science data standards. This document is complemented by the nc-eTAG GitHub repository (10.6084/m9.figshare.10055603) that has been established. It contains the CDL template files themselves, more detailed electronic tagging metadata profile documentation, and other relevant resources.

This guide to the nc-eTAG specification is structured as follows: Section 2 describes methods employed to derive the template specifications. Section 3 provides the template CDL listings for each of the three core tag data types covered. Section 4 describes the utilization of Group structures associated with the netCDF Enhanced Data Model to encapsulate rich sets of tag and other metadata. Section 5 outlines an approach for multiple tag dataset support within single netCDF data files. Section 6 provides some recommendations on the use of select advanced features of the netCDF Enhanced Data Model and the netCDF-4 file format (chunking/data compression, groups) when implementing the nc-eTAG specification

2 Methods

Foundational analyses and background information, documented by OIIP previously and that went into the development of the netCDF (nc) eTAG (electronic tagging) templates discussed below, will not be repeated at length here. Readers should consult those documents for further details [1, 2] and also the source CF, ACDD and netCDF technical standards documentation upon which the nc-eTAG are ultimately based [4, 5, 6, 7, 8, 9, 10]. Here we provide just the key information needed to understand the nc-eTAG template specifications themselves.

The templates are designed to support the range of key tagging data type classes - satellite positional, archival and retrieved popup satellite archival (PSAT) trajectory series, and PSAT transmitted summary data- and associated output data representations being produced by tag manufacturers. Examples of a representative range of electronic tag dataset types from different manufacturers that were reviewed prior to nc-eTAG template formulation are summarized in Table 1 below. These also include datasets involving tag data for a given deployment where instrument outputs are at different or varying measurement frequencies (eg. Periodic high frequency measurement bursts and tag sensors sampling at different frequencies). Representative examples of manufacturer instrument data output files associated with the range of tag types that the nc-eTAG templates are designed to support are presented in the Appendix and discussed in more detail in [1]. As described therein, metadata natively present with the standard tag manufacturer instrument data file outputs generally is cursory at best. The rich suite of metadata attributes needed to fully describe aspects of electronic tag instrument deployments for reproducible science utilization and data preservation purposes are described in [2] together with recommendations on the packaging of such domain metadata within self-describing netCDF data files together with the standard CF and ACDD geospatial metadata attributes. Compiled, reviewed and based on inputs from domain experts and tagging practitioners, eTAG metadata are included in the nc-eTAG template specifications below consistent with prior our recommendations [2].

Table 1. Representative range of sample electronic tag dataset types

Manufacturer	Type	Model	Processing Tool Version	Format	File	Data/Header Complexity	Notes	Provider	Species/TagID
Wildlife Computers	Popup/ Transmitting	MiniPAT	DAP 3.0 Build 434 (Desktop version)	.csv	Popup_WildlifeComputers.7z	High; try this second to last	Spreadsheet header	LPRC	Sailfish/ 113674
								LPRC	Sailfish/ 142389
Microwave Telemetry	Popup/ Transmitting	X-tag	Manufacturer processed in-house	.xls	Popup_MicrowaveTelemetry.7z	High; try this last		LPRC	Sailfish/ 117259
Wildlife Computers	Implanted/ Archival	Mk-9	Instrument Helper	.csv	Archival_WildlifeComputers.7z	Simple / Medium	Very detailed time series	IATTC	Bigeye tuna/ 0390075
			DAP 3.0 Build 434 (Desktop version)	.csv			Spreadsheet header Very detailed time series	IATTC	Bigeye tuna/ 0590051
			Likely Instrument Helper	.csv			Detailed time series	ATN	Albacore tuna/ 1204043
Lotek	Implanted/ Archival		Viewer 2000	.csv	Archival_LotekWireless.7z	Simple; try first	Very detailed time series	IATTC	Yellowfin tuna/ A0525
							Very detailed time series	IATTC	Yellowfin tuna/ C0066

3 nc-eTAG Templates

This section provides the detailed CDL template specification for encoding of the key classes of (non-acoustic) electronic tagging datasets in netCDF consistent with prevailing Earth Science data interoperability standards. Three nc-eTAG templates are available for download as CDL (ASCII) text files with additional supporting materials from the nc-eTAG GitHub repository:

- nc-eTAG_Archival_Template.cdl
- nc-eTAG_Archival-LFHF_Template.cdl
- nc-eTAG_PSATsummarydata_Template.cdl

Comments and contributions to this open community resource by domain experts are encouraged. Appropriate citation of this reference document (10.6084/m9.figshare.10159820) and acknowledgement of the NASA/ACCESS15-0017 Oceanographic In-situ data Interoperability Project (OIIP) is appreciated.

Note that these templates are not intended to capture every possible variable electronic tags measure now or will measure in the future. They do, however, provide a comprehensive roadmap for implementation for all the key categories of data and variables for storage in netCDF structures. This includes: 1) ***global and variable level metadata*** attributes, involving both tag domain specific and CF/ACDD geospatial attributes, and 2) standards compliant data structures supporting both ***coordinate variable*** data (eg. Latitude, Longitude, Time, Depth), and ***geophysical measurement variable*** data (eg. Light level, Temperature etc). The block organization of the CDL templates below reflect these fundamental structural elements. As new sensor measurements become available over time, additional data structures following the same specifications and patterns outlined in the templates can simply be added to implementations.

A global metadata block, comprised largely of comparable attribute elements but with some customized elements where necessary, is present in each of the three CLD templates. Variations in tag-related metadata groups associated with the global level attributes reflect the need to capture additional descriptive information elements that may pertain to one category or class of electronic tags but perhaps not another. Differences between templates are primarily in some aspect of either the coordinate or geophysical measurement variables. These are necessary and reflect fundamental differences in the structure/representation of data for the different tag data types/classes (eg. continuous trajectory archival series vs transmitted summary data types).

Metadata attribute values present in the templates are intended as illustrative examples of values that the given attribute should take. Template implementation for any given dataset will obviously require substitution of those values with ones applicable to the given dataset and attribute in question. These substituted values should though be of the same attribute data type (eg. string, integer, double etc.).

For readers unfamiliar with the netCDF-CF and ACDD standards and NCEI implementation guidelines for in-situ data upon which the nc-eTAG templates here are based, please consult the following reference material for the necessary background: 6, 7, 8, 9, 10. The nc-eTAG templates take advantage of hierarchical “Group” structures already supported by the netCDF Enhanced Data Model to systematically represent rich sets of tagging domain metadata attributes that are organized categorically [2]. Groups are also integral and a primary new addition to the latest Climate Forecast (CF) version standards that are being finalized. Usage of Groups where necessary in the nc-eTAG template specifications ensures that nc-eTAG templates will be compatible with the most current Earth Science data and metadata interoperability standards going forwards. Note that until the CF Groups proposal [11] is published as part of the CF specification, we suggest that the typical set of CF and ACDD global file attributes that are also integral to nc-eTAG specification be kept outside of Group structures of their own. This recommendation that the usage of Groups be reserved for the packaging of tagging metadata within the global file attributes

block for the time being is reflected in the template specifications below. Once the CF Group proposal has been published, encapsulation of the CF and ACDD attributes within Groups of their own within the global file metadata block is recommended [2]. Such an approach ensures modular incorporation of additional, new community metadata standards that may emerge in future while also facilitating self-contained updates to logical structural metadata containers where necessary. Section 4 describes such adaptations to the baseline nc-eTAG templates presented below.

The nc-eTAG template specifications here are directly applicable for storage of instrument data from a single electronic tag of a given type in a single archive quality, standards compliant netCDF data file. Storage of data from one tag in a single file is the recommended approach. Aggregation and operations on catalogues of multiple tag data files can be achieved via data server technologies such as THREDDS. This approach and utility is widely used for the distribution of collections of standards compliant netCDF files with Earth Science data of various types.

However, the CF data model also natively supports the packaging of data from multiple “features”, or tag deployments in our case, in a single file. A practical constraint to this though is supporting the metadata for multiple tags that somehow would need to be distinguishable and systematically organized within the global file metadata attributes. With the netCDF Enhanced Data Model and the advent of Groups, this is now possible by extensions further leveraging the use of Groups to hierarchically store blocks of logically organized attributes by tag/feature, with subgroups containing the CF, ACDD, and 10 categories of electronic tag metadata attributes. The approach is outlined in section 5.

Archival Tag Data Template

nc-eTAG_Archival_Template.cdl

This nc-eTAG (Archival) template applies to archival and retrieved popup satellite archival (PSAT) trajectory series datasets.

```
netcdf file\:/C\:/ nc-eTAG_Archival_Template {
  dimensions:
    time = 2046391;
    str_len = 6;

  variables:

  //Coordinate and Auxiliary Coordinate Variables

   char trajectory(str_len);
      string trajectory:cf_role = "trajectory_id";

   double time(time);
      string time:long_name = "Time of observation";
      string time:standard_name = "time";
      string time:units = "seconds since 1970-01-01T00:00:00";  // UTC
      string time:axis = "T";
      string time:coverage_content_type = "coordinate";

   double location_freshness(time);
      string location_freshness:long_name = "location_freshness";
      string location_freshness:comment = "time since last latitude and longitude
                                          observations";
      string location_freshness:units = "seconds";
      double location_freshness:_FillValue = -999999;
      double location_freshness:valid_max = 86340.0;
      double location_freshness:valid_min = 0.0;
      string location_freshness:coverage_content_type = "auxiliaryInformation";

   double longitude(time);
      string longitude:long_name = "estimated longitude";
      string longitude:standard_name = "longitude";
      string longitude:units = "degrees_east";
      string longitude:axis = "X";
      double longitude:_FillValue = -999999;
      double longitude:valid_max = -118.48636166666667;
      double longitude:valid_min = -127.43765333333333;
      string longitude:ancillary_variables = "longitude_uncertainty";
      string longitude:coverage_content_type = "coordinate";

   double longitude_uncertainty(time);
      string longitude_uncertainty:long_name = "derived uncertainty around longitude
                                               estimate";
      string longitude_uncertainty:standard_name = "longitude standard_error";
      string longitude_uncertainty:units = "degrees ";
```

```
    double longitude_uncertainty:_FillValue = -999999;
    double longitude_uncertainty:valid_max = 0.05;
    double longitude_uncertainty:valid_min = 0.01;
    string longitude_uncertainty:coverage_content_type = "qualityInformation";

 double latitude(time);
    string latitude:long_name = "estimated latitude";
    string latitude:standard_name = "latitude";
    string latitude:units = "degrees_north";
    string latitude:axis = "Y";
    double latitude:_FillValue = -999999;
    double latitude:valid_max = 30.639526666666665;
    double latitude:valid_min = 9.908965;
    string latitude:ancillary_variables = "latitude_uncertainty";
    string latitude:coverage_content_type = "coordinate";

 double latitude_uncertainty(time);
    string latitude_uncertainty:long_name = "derived uncertainty around latitude estimate";
    string latitude_uncertainty:standard_name = "latitude standard_error";
    string latitude_uncertainty:units = "degrees ";
    double latitude_uncertainty:_FillValue = -999999;
    double latitude_uncertainty:valid_max = 0.05;
    double latitude_uncertainty:valid_min = 0.01;
    string latitude_uncertainty:coverage_content_type = "qualityInformation";

 double depth(time);
    string depth:long_name = "measured depth";
    string depth:standard_name = "depth";
    string depth:units = "m";
    string depth:axis = "Z";
    string depth:positive = "down";
    double depth:_FillValue = -999999;
    double depth:valid_max = 563.639526666666665;
    double depth:valid_min = 0.0000000000001;
    string depth:coverage_content_type = "coordinate";

//Geophysical measurement Variables

 double external_temperature(time);
    string external_temperature:long_name = "sea water wemperature";
    string external_temperature:standard_name = "sea_water_temperature";
    string external_temperature:units = "degrees_C";
    double external_temperature:_FillValue = -999999;
    double external_temperature:valid_max = 30.6457;
    double external_ temperature:valid_min = 20.354621874999996;
    string external_temperature:coordinates = "time latitude longitude depth trajectory";
    string external_temperature:coverage_content_type = "physicalMeasurement";

 double internal_temperature(time);
    string internal_temperature:long_name = "internal body temperature";
    string internal_temperature:units = "degrees_C";
    double internal_temperature:_FillValue = -999999;
    double internal_temperature:valid_max = 27.75;
```

```
    double internal_temperature:valid_min = 19.200000762939453;
    string internal_temperature:coordinates = "time latitude longitude depth trajectory";
    string internal_temperature:coverage_content_type = "physicalMeasurement";

 double illuminance(time);
    string illuminance:long_name = "light level";
    string illuminance:units = "lux";
    double illuminance:_FillValue = -999999;
    double illuminance:valid_max = 173.0;
    double illuminance:valid_min = 33.0;
    string illuminance:coordinates = "time latitude longitude depth trajectory";
    string illuminance:coverage_content_type = "physicalMeasurement";

// Global attributes:
  // CF-ACDD global attributes

  string :Conventions = "CF-1.7, ACDD 1.3, COARDS";
  string :Metadata_Conventions = "Unidata Dataset Discovery v1.3";
  string :featureType = "trajectory";
  string :cdm_data_type = "Trajectory";
  string :nodc_template_version = "NODC_NetCDF_Trajectory_Template_v2.0, ATN extension";
  string :standard_name_vocabulary = "CF Standard Name Table v27";
  string :title = "Animal telemetry archival tag netCDF template";
  string :source = "atn.noaa.gov";
  string :platform = "Thunnus obesus";
  string :instrument = "Wildlife Computers MK9";
  string :uuid = "70e37fb7-da57-4dee-81f4-f965a3c08762";
  string :id = "10.5067/ATN_00001";   // Dataset DOI
  string :metadata_link = "https://atn.noaa.gov/dataset/ATN_00001"
  string :references = "Fuller, Daniel & Schaefer, Kurt & Hampton, John & Caillot, Sylvain &
                        Leroy, Bruno & Itano, David. (2015). Vertical movements,
                        behavior, and habitat of bigeye tuna (Thunnus obesus) in the
                        equatorial central Pacific Ocean. Fisheries Research. 172. 57-70.
                        10.1016/j.fishres.2015.06.024.";
  string :sea_name = "Pacific";
  string :naming_authority = "gov.noaa.gov.atn";
  string :time_coverage_start = "2014-08-07T07:33:30";
  string :time_coverage_end = "2014-08-31T00:00:00";
  string :time_coverage_resolution = "PT1S";  //alter time interval of data accordingly
  double :geospatial_lat_min = 9.908965;
  double :geospatial_lat_max = 30.639526666666665;
  string :geospatial_lat_units = "degrees_north";
  string :geospatial_lat_resolution = "0.1 degree";
  double :geospatial_lon_min = -127.43765333333333;
  double :geospatial_lon_max = -118.48636166666667;
  string :geospatial_lon_units = "degrees_east";
  string :geospatial_lon_resolution = "0.1 degree";
  double :geospatial_vertical_min = 500.000;
  double :geospatial_vertical_max = 0.000;
  string :geospatial_vertical_units = "m";
  string :geospatial_vertical_resolution = "10 meters";
  string :creator_type = "institution";
  string :creator_institution = "Inter-American Tropical Tuna Commission (IATTC)";
  string :creator_email = "kschaefer@iattc.org";
```

```
 string :creator_name = "Schaefer, Kurt";
 string :creator_role = "Researcher";
 string :institution = "Inter-American Tropical Tuna Commission (IATTC)";
 string :publisher_name = "Vardis Tsontos";
 string :publisher_type = "person";
 string :publisher_email = "vtsontos@jpl.nasa.gov";
 string :publisher_url = "https://podaac.jpl.nasa.gov/";
 string :project = "IATTC Bigeye tuna behavior program";
 string :processing_level = "Level 2";
 string :keywords_vocabulary = "CF Standard Names, GCMD Science Keywords";  // add keyword
                                                                    citation as necessary
 string :keywords = "Temperature, electronic tag, animal telemetry, bigeye, tuna, Thunnus
                     obesus, IATTC, Eastern Tropical Pacific Ocean";
 string :acknowledgement = "Funding provided by IATTC under grant 2019-XYZ.";
 string :date_created = "2019-09-18T13:53:21";
 string :date_modified = "2019-09-18T13:53:21";
 string :date_issued = "2019-09-18T13:53:21";
 string :date_metadata_modified = "2019-09-18T13:53:21";
 string :program = "IATTC Tuna Behavior and Life History";
 string :product_version = "1.0";
 string :license = "IATTC data are copyrighted and available publicly on condition of
                         institution and researcher citation.";
 string :summary = "Implanted archival tag dataset showing the migration and diving
                   patterns of an adult Bigeye tuna in the Eastern Tropical Pacific
                   courtesy of Kurt Schaefer and Dan Fuller of the IATTC";

 // Animal Telemetry domain global attributes organized by category in Group structures

group: Meta_eTag {
   group: animal {
     string :platformUUID = "123e4567-e89b-12d3-a456-426655440000";          //REQUIRED
     string :platform = "Thunnus obesus";                                    //REQUIRED
     string :taxonomic_serial_number = "172428";                             //REQUIRED
     string :length_type_capture = "Straight fork length";                   //REQUIRED
     string :length_method_capture = "measured caliper";                     //REQUIRED
     double :length_capture = 67.0f;                                         //REQUIRED
     string :length_unit_capture = "cm";                                     //REQUIRED
     string :condition_capture = "good";                                     //REQUIRED
     string :lifestage_capture = "juvenile";                                 //recommended
     string :length_type_recapture = "Straight fork length";                 //recommended
     string :length_method_recapture = "predicted";                          //recommended
     double :length_recapture = 159.0f;                                      //recommended
     string :length_unit_recapture = "cm";                                   //recommended
     string :condition_recapture = "gut hooked";                             //recommended
     string :fate_recapture = "harvested";                                   //recommended
     string :lifestage_recapture = "adult";                                  //recommended
     string :tag_placement = "body cavity";                                  //recommended
     double :hours_soaktime_capture = 0.1f;                                  //optional
     double :hours_soaktime_recapture = 1.5f;                                //optional
     integer :implant_numsuture = 3;                                         //optional
     double :minutes_operation = 0.5f;                                       //optional
     double :minutes_revival = 1.0f;                                         //optional
     string :sex = "unknown";                                                //optional
```

```
  string :stock = "unknown";                                          //optional
  string :tissue_sample_capture = "Blood-ID02101";                    //optional
  string :tissue_sample_recapture = "Blood-ID02102";                  //optional
  string :weight_type_capture = "whole";                              //optional
  string :weight_method_capture = "measured";                         //optional
  double :weight_capture = 1200.0f;                                   //optional
  string :weight_unit_capture = "g";                                  //optional
  string :weight_type_recapture = "dressed";                          //optional
  string :weight_method_recapture = "measured";                       //optional
  double :weight_recapture = 2700.0f;                                 //optional
  string :weight_unit_recapture = "g";                                //optional
  }

group: attachment {
  string :attachment_method = "anchor";                               //REQUIRED
  string :anesthetic_product = "metomidate";                          //optional
  string :antifouling_product = " Micron66";                          //optional
  }

group: ancillary_positions {
  string :ancillary_position_source = "Acoustic detections";          //optional
  string :ancillary_position_instrumentid = "receiverID1003, receiverID1008,
                                          receiverID1121";            //optional
  string :datetime_ancillary_position = "2016-01-04 22:32:21, 2016-02-01 02:41:11,
                                          2016-03-29 09:15:31";       //optional
  string :ancillary_position_lon = "-153.42,-152.42,-152.49";         //optional
  string :ancillary_position_lat = "42.131,41.135,42.422";            //optional
  string :ancillary_position_quality = " LC0,LC1,LCA";                //optional
  }

group: deployment {
  string :time_coverage_start = "2005-04-15";                         //REQUIRED
  double :geospatial_lon_start = -95.18f;                             //REQUIRED
  double :geospatial_lat_start = -1.94f;                              //REQUIRED
  string :person_tagger_capture = "D. Fuller";                        //REQUIRED
  string :location_capture = "Catalina Island";                       //recommended
  string :method_capture = "longline";                                //recommended
  string :baitlure_capture = "sardine";                               //optional
  string :cruise_capture = "SPURS2";                                  //optional
  double :depth_m_capture = 10.0f;                                    //optional
  string :flag_capture = "USA";                                       //optional
  string :hook_capture = "18/0 circle";                               //optional
  string :method_aboard = "net";                                      //optional
  string :othertags_capture = "Hallprint PAR007007";                  //optional
  string :person_angler_capture = "D. Fuller";                        //optional
  string :school_capture = "FAD";                                     //optional
  string :seastate_capture = "rough";                                 //optional
  string :set_float_capture = "10";                                   //optional
  string :station_capture = "TAO-10";                                 //optional
  double :temp_degC_capture = 13.5f;                                  //optional
  string :vessel_capture = "R/V Endeavor";                            //optional
  double :wind_knots_capture = 8.3f;                                  //optional
  }
```

```
group: end_of_mission {
  string :time_coverage_end = "2009-07-02";                                  //REQUIRED
  string :geospatial_lon_end = -83.98f;                                      //REQUIRED
  string :geospatial_lat_end = -1.45f;                                       //REQUIRED
  string :end_details = "recovered by fishing fleet";                        //REQUIRED
  string :end_type = "recaptured";                                           //REQUIRED
  string :datetime_death = "2017-07-11T18:24:23+00:00";                      //optional
  }

group: instrument {
  string :instrument_name = "16P0100-Refurb2";                               //REQUIRED
  string :instrument_type = "archival";                                      //REQUIRED
  string :firmware = "1235";                                                 //REQUIRED
  string :manufacturer = "Wildlife Computers";                               //REQUIRED
  string :model = "Mk 9";                                                    //REQUIRED
  string :person_owner = "Kurt Schaefer";                                    //REQUIRED
  string :owner_contact = "kschaefer@iattc.org";                             //REQUIRED
  string :serial_number = "590051";                                          //REQUIRED
  string :date_shipment = "2017-07-11T18:24:23+00:00";                       //recommended
  string :project = "SPURS2";                                                //recommended
  string :specs = "Manufacturer WC- MK9model URI";                           //recommended
  }

group: programming {
  string :programming_report = "URI to report";                              //REQUIRED
  string :programming_software = "WC-prg-v3";                                //REQUIRED
  string :date_programming = "2008-11-02";                                   //REQUIRED
  integer :days_mission = 365;                                               //recommended
  integer :minutes_summary = 1440";                                          //recommended
  string :person_programmer = "Kurt Schaefer";                               //recommended
  integer :seconds_sampling = 15;                                            //recommended
  integer :seconds_writingdata = 300;                                        //recommended
  integer :seconds_sampling_highfreq = 100;                                  //optional
  }

group: quality {
  string :found_problem = "no";                                              //REQUIRED
  string :person_qc = "Dan Fuller";                                          //REQUIRED
  string :problem_affecteddates = "2008-10-02 to 2008-11-30";                //recommended
  string :problem_details = "Daily drift after sunset by 1.5 degC";          //recommended
  integer:problem_numof = 1;                                                 //recommended
  string :problem_summary = "Temperature sensor drift";                      //recommended
  string :calibration_file = "URL to sensor calibration document";           //optional
  }

group: recovery {
  string :location_recapture = "San Pedro Channel";                          //recommended
  string :method_recapture = "longline";                                     //recommended
  string :person_recapture = "Kurt Schaefer";                                //recommended
  string :baitlure_recapture = "sardine";                                    //optional
  string :cruise_recapture = "Spurs3";                                       //optional
  double :depth_m_recapture = 10.0f;                                         //optional
```

```
    string :flag_recapture = "Chile";                                          //optional
    string :hook_recapture = "18/0 Circle";                                    //optional
    string :person_tagger_recapture = "Kurt Schaefer";                         //optional
    string :retagged_recapture = "Hallprint PAR007007";                        //optional
    string :school_recapture = "FAD";                                          //optional
    string :seastate_recapture = "calm";                                       //optional
    string :set_float_recapture = "160";                                       //optional
    string :station_recapture = "TAO-12";                                      //optional
    double :temp_degC_recapture = 12.6f;                                       //optional
    string :vessel_recapture = "R/V Gamboa";                                   //optional
    double :wind_knots_recapture = 6f;                                         //optional
    }

  group: waypoints {
    string :waypoints_source = "modeled";                                      //REQUIRED
    string :waypoints_method = "ukfsst";                                       //recommended
    string :geolocation_parameters = "diffusion_coefficien:0.3, MUR-SST";      //recommended
    string :interpolation_method = "crawl";                                    //recommended
    string :interpolation_time = "gap filling";                                //recommended
    string :waypoints_software = "UKFSST_v3";                                  //recommended
    string :geolocation_output = ftp://myserver/myfiles.zip;                   //optional
    }
  }
}
```

High & Low Frequency Sensor Measurement Archival Tag Data Template

nc-eTAG_Archival-LFHF_Template.cdl

This nc-eTAG (HFLF) template applies to the subclass of archival-type datasets produced by tags of some manufacturers (eg. Microwave Telemetry) involving instrument outputs at different or varying measurement frequencies: periodic high frequency measurement bursts at pre-programmed time intervals, and/or tag sensors sampling and recording observations at different frequencies.

```
netcdf file\:/C\:/ nc-eTAG_Archival-LFHF_Template {
  dimensions:
    time = 2046391;
    HFtime = 1000000;
    str_len = 6;

  variables:

  //Coordinate and Auxiliary Coordinate Variables

   char trajectory(str_len);
      string trajectory:cf_role = "trajectory_id";

   double time(time);
      string time:long_name = "Time of observation";
      string time:standard_name = "time";
      string time:units = "seconds since 1970-01-01T00:00:00";  // UTC
      string time:axis = "T";
      string time:coverage_content_type = "coordinate";

   double location_freshness(time);
      string location_freshness:long_name = "location_freshness";
      string location_freshness:comment = "time since last latitude and longitude
                                           observations";
      string location_freshness:units = "seconds";
      double location_freshness:_FillValue = -999999;
      double location_freshness:valid_max = 86340.0;
      double location_freshness:valid_min = 0.0;
      string location_freshness:coverage_content_type = "auxiliaryInformation";

   double HFlocation_freshness(HFtime);
      string HFlocation_freshness:long_name = "location_freshness for high frequency
                                               observation periods";
      string HFlocation_freshness:comment = "time since last latitude and longitude high
                                               frequency observations";
      string HFlocation_freshness:units = "seconds";
      double HFlocation_freshness:_FillValue = -999999;
      double HFlocation_freshness:valid_max = 25340.0;
      double HFlocation_freshness:valid_min = 0.0;
      string HFlocation_freshness:coverage_content_type = "auxiliaryInformation";

   double longitude(time);
      string longitude:long_name = "estimated longitude";
      string longitude:standard_name = "longitude";
```

```
   string longitude:units = "degrees_east";
   string longitude:axis = "X";
   double longitude:_FillValue = -999999;
   double longitude:valid_max = -118.48636166666667;
   double longitude:valid_min = -127.43765333333333;
   string longitude:ancillary_variables = "longitude_uncertainty";
   string longitude:coverage_content_type = "coordinate";

double longitude_uncertainty(time);
   string longitude_uncertainty:long_name = "derived uncertainty around longitude
                                            estimate";
   string longitude_uncertainty:standard_name = "longitude standard_error";
   string longitude_uncertainty:units = "degrees";
   double longitude_uncertainty:_FillValue = -999999;
   double longitude_uncertainty:valid_max = 0.05;
   double longitude_uncertainty:valid_min = 0.01;
   string longitude_uncertainty:coverage_content_type = "qualityInformation";

double latitude(time);
   string latitude:long_name = "estimated latitude";
   string latitude:standard_name = "latitude";
   string latitude:units = "degrees_north";
   string latitude:axis = "Y";
   double latitude:_FillValue = -999999;
   double latitude:valid_max = 30.639526666666665;
   double latitude:valid_min = 9.908965;
   string latitude:ancillary_variables = "latitude_uncertainty";
   string latitude:coverage_content_type = "coordinate";

double latitude_uncertainty(time);
   string latitude_uncertainty:long_name = "derived uncertainty around latitude estimate";
   string latitude_uncertainty:standard_name = "latitude standard_error";
   string latitude_uncertainty:units = "degrees";
   double latitude_uncertainty:_FillValue = -999999;
   double latitude_uncertainty:valid_max = 0.05;
   double latitude_uncertainty:valid_min = 0.01;
   string latitude_uncertainty:coverage_content_type = "qualityInformation";

double depth(time);
   string depth:long_name = "measured depth";
   string depth:standard_name = "depth";
   string depth:units = "m";
   string depth:axis = "Z";
   string depth:positive = "down";
   double depth:_FillValue = -999999;
   double depth:valid_max = 500.000;
   double depth:valid_min = 0.000;
   string depth:coverage_content_type = "coordinate";

double HFtime(HFtime);
   string HFtime:long_name = "Time of high frequency observation periods";
   string HFtime:standard_name = "time";
   string HFtime:units = "seconds since 1970-01-01T00:00:00";  // UTC
```

```
   string HFtime:axis = "T";
   string HFtime:coverage_content_type = "coordinate";

double HFlongitude(HFtime);
   string HFlongitude:long_name = "estimated longitude for high frequency observation
                                   periods";
   string HFlongitude:standard_name = "longitude";
   string HFlongitude:units = "degrees_east";
   string HFlongitude:axis = "X";
   double HFlongitude:_FillValue = -999999;
   double HFlongitude:valid_max = -118.48636166666667;
   double HFlongitude:valid_min = -127.43765333333333;
   string HFlongitude:ancillary_variables = "HFlongitude_uncertainty";
   string HFlongitude:coverage_content_type = "coordinate";

double HFlongitude_uncertainty(HFtime);
   string HFlongitude_uncertainty:long_name = "derived uncertainty around longitude
                                   estimate for high frequency observation periods";
   string HFlongitude_uncertainty:standard_name = "longitude standard_error";
   string HFlongitude_uncertainty:units = "degrees";
   double HFlongitude_uncertainty:_FillValue = -999999;
   double HFlongitude_uncertainty:valid_max = 0.05;
   double HFlongitude_uncertainty:valid_min = 0.01;
   string HFlongitude_uncertainty:coverage_content_type = "qualityInformation";

double HFlatitude(HFtime);
   string HFlatitude:long_name = "estimated latitude for high frequency observation
                                   periods";
   string HFlatitude:standard_name = "latitude";
   string HFlatitude:units = "degrees_north";
   string HFlatitude:axis = "Y";
   double HFlatitude:_FillValue = -999999;
   double HFlatitude:valid_max = 30.639526666666665;
   double HFlatitude:valid_min = 9.908965;
   string HFlatitude:ancillary_variables = "latitude_uncertainty";
   string HFlatitude:coverage_content_type = "coordinate";

double HFlatitude_uncertainty(HFtime);
   string HFlatitude_uncertainty:long_name = "derived uncertainty around latitude estimate
                                              for high frequency observation periods";
   string HFlatitude_uncertainty:standard_name = "latitude standard_error";
   string HFlatitude_uncertainty:units = "degrees";
   double HFlatitude_uncertainty:_FillValue = -999999;
   double HFlatitude_uncertainty:valid_max = 0.05;
   double HFlatitude_uncertainty:valid_min = 0.01;
   string HFlatitude_uncertainty:coverage_content_type = "qualityInformation";

double HFdepth(HFtime);
   string HFdepth:long_name = "measured depth for high frequency observation periods";
   string HFdepth:standard_name = "depth";
   string HFdepth:units = "m";
   string HFdepth:axis = "Z";
   string HFdepth:positive = "down";
```

```
    double HFdepth:_FillValue = -999999;
    double HFdepth:valid_max = 500.000;
    double HFdepth:valid_min = 0.000;
    string HFdepth:coverage_content_type = "coordinate";

//Geophysical measurement Variables

 double external_temperature(time);
    string external_temperature:long_name = "sea water wemperature";
    string external_temperature:standard_name = "sea_water_temperature";
    string external_temperature:units = "degrees_C";
    double external_temperature:_FillValue = -999999;
    double external_temperature:valid_max = 30.6457;
    double external_temperature:valid_min = 20.354621874999996;
    string external_temperature:coordinates = "time latitude longitude depth trajectory";
    string external_temperature:coverage_content_type = "physicalMeasurement";

 double internal_temperature(time);
    string internal_temperature:long_name = "internal body temperature";
    string internal_temperature:units = "degrees_C";
    double internal_temperature:_FillValue = -999999;
    double internal_temperature:valid_max = 27.75;
    double internal_temperature:valid_min = 19.200000762939453;
    string internal_temperature:coordinates = "time latitude longitude depth trajectory";
    string temperature:coverage_content_type = "physicalMeasurement";

 double illuminance(time);
    string illuminance:long_name = "light level";
    string illuminance:units = "lux";
    double illuminance:_FillValue = -999999;
    double illuminance:valid_max = 173.0;
    double illuminance:valid_min = 33.0;
    string illuminance:coordinates = "time latitude longitude depth trajectory";
    string illuminance:coverage_content_type = "physicalMeasurement";

 double HFexternal_temperature(HFtime);
    string HFexternal_temperature:long_name = "High frequency sea water temperature
                                               observations";
    string HFexternal_temperature:standard_name = "sea_water_temperature";
    string HFexternal_temperature:units = "degrees_C";
    double HFexternal_temperature:_FillValue = -999999;
    double HFexternal_temperature:valid_max = 30.6457;
    double HFexternal_temperature:valid_min = 20.354621874999996;
    string HFexternal_temperature:coordinates = "HFtime HFlatitude HFlongitude HFdepth
                                                 trajectory";
    string HFexternal_temperature:coverage_content_type = "physicalMeasurement";
    string HFexternal_temperature:comment = "External temperature measurements during high
                                             frequency sensor measurement periods";

 double HFinternal_temperature(HFtime);
    string HFinternal_temperature:long_name = "High frequency internal body temperature";
    string HFinternal_temperature:units = "degrees_C";
    double HFinternal_temperature:_FillValue = -999999;
```

```
    double HFinternal_temperature:valid_max = 27.75;
    double HFinternal_temperature:valid_min = 19.200000762939453;
    string HFinternal_temperature:coordinates = "HFtime HFlatitude HFlongitude HFdepth
                                                 trajectory";
    string HFinternal_temperature:coverage_content_type = "physicalMeasurement";
    string HFinternal_temperature:comment = "Internal temperature measurements during high
                                                 frequency sensor measurement periods";

 double HFilluminance(HFtime);
    string HFilluminance:long_name = "High frequency light level";
    string HFilluminance:units = "lux";
    double HFilluminance:_FillValue = -999999;
    double HFilluminance:valid_max = 173.0;
    double HFilluminance:valid_min = 33.0;
    string HFilluminance:coordinates = "HFtime HFlatitude HFlongitude HFdepth trajectory";
    string HFilluminance:coverage_content_type = "physicalMeasurement";
    string HFilluminance:comment = "Light level measurements during high frequency sensor
                                        measurement periods";

// Global attributes:
  // CF-ACDD global attributes

  string :Conventions = "CF-1.7, ACDD 1.3, COARDS";
  string :Metadata_Conventions = "Unidata Dataset Discovery v1.3";
  string :featureType = "trajectory";
  string :cdm_data_type = "Trajectory";
  string :nodc_template_version = "NODC_NetCDF_Trajectory_Template_v2.0, ATN extension";
  string :standard_name_vocabulary = "CF Standard Name Table v27";
  string :title = "Animal telemetry archival HF/LF tag netCDF template";
  string :source = "atn.noaa.gov";
  string :platform = "Thunnus obesus";
  string :instrument = "Wildlife Computers MK9";
  string :uuid = "70e37fb7-da57-4dee-81f4-f965a3c08762";
  string :id = "10.5067/ATN_00001";   // Dataset DOI
  string :metadata_link = "https://atn.noaa.gov/dataset/ATN_00001"
  string :references = "Fuller, Daniel & Schaefer, Kurt & Hampton, John & Caillot, Sylvain &
                        Leroy, Bruno & Itano, David. (2015). Vertical movements,
                        behavior, and habitat of bigeye tuna (Thunnus obesus) in the
                        equatorial central Pacific Ocean. Fisheries Research. 172. 57-70.
                        10.1016/j.fishres.2015.06.024.";
  string :sea_name = "Pacific";
  string :naming_authority = "gov.noaa.gov.atn";
  string :time_coverage_start = "2014-08-07T07:33:30";
  string :time_coverage_end = "2014-08-31T00:00:00";
  string :time_coverage_resolution = "PT1S";  //alter time interval of data accordingly
  double :geospatial_lat_min = 9.908965;
  double :geospatial_lat_max = 30.639526666666665;
  string :geospatial_lat_units = "degrees_north";
  string :geospatial_lat_resolution = "0.1 degree";
  double :geospatial_lon_min = -127.43765333333333;
  double :geospatial_lon_max = -118.48636166666667;
  string :geospatial_lon_units = "degrees_east";
  string :geospatial_lon_resolution = "0.1 degree";
```

```
 double :geospatial_vertical_min = 500.000;
 double :geospatial_vertical_max = 0.000;
 string :geospatial_vertical_units = "m";
 string :geospatial_vertical_resolution = "10 meters";
 string :creator_type = "institution";
 string :creator_institution = "Inter-American Tropical Tuna Commission (IATTC)";
 string :creator_email = "kschaefer@iattc.org";
 string :creator_name = "Schaefer, Kurt";
 string :creator_role = "Researcher";
 string :institution = "Inter-American Tropical Tuna Commission (IATTC)";
 string :publisher_name = "Vardis Tsontos";
 string :publisher_type = "person";
 string :publisher_email = "vtsontos@jpl.nasa.gov";
 string :publisher_url = "https://podaac.jpl.nasa.gov/";
 string :project = "IATTC Bigeye tuna behavior program";
 string :processing_level = "Level 2";
 string :keywords_vocabulary = "CF Standard Names, GCMD Science Keywords";
 string :keywords = "Temperature, electronic tag, animal telemetry, bigeye, tuna, Thunnus
                         obesus, IATTC, Eastern Tropical Pacific Ocean";
 string :acknowledgement = "Funding provided by IATTC under grant 2019-XYZ.";
 string :date_created = "2019-09-18T13:53:21";
 string :date_modified = "2019-09-18T13:53:21";
 string :date_issued = "2019-09-18T13:53:21";
 string :date_metadata_modified = "2019-09-18T13:53:21";
 string :program = "IATTC Tuna Behavior and Life History";
 string :product_version = "1.0";
 string :license = "IATTC data are copyrighted and available publicly on condition of
                         institution and researcher citation.";
 string :summary = "Implanted archival tag dataset showing the migration and diving
                   patterns of an adult Bigeye tuna in the Eastern Tropical Pacific
                   courtesy of Kurt Schaeffer and Dann Fuller of the IATTC";

// Animal Telemetry domain global attributes organized by category in Group structures

group: Meta_eTag {
   group: animal {
     string :platformUUID = "123e4567-e89b-12d3-a456-426655440000";          //REQUIRED
     string :platform = "Thunnus obesus";                                    //REQUIRED
     string :taxonomic_serial_number = "172428";                             //REQUIRED
     string :length_type_capture = "Straight fork length";                   //REQUIRED
     string :length_method_capture = "measured caliper";                     //REQUIRED
     double :length_capture = 67.0f;                                         //REQUIRED
     string :length_unit_capture = "cm";                                     //REQUIRED
     string :condition_capture = "good";                                     //REQUIRED
     string :lifestage_capture = "juvenile";                                 //recommended
     string :length_type_recapture = "Straight fork length";                 //recommended
     string :length_method_recapture = "predicted";                          //recommended
     double :length_recapture = 159.0f;                                      //recommended
     string :length_unit_recapture = "cm";                                   //recommended
     string :condition_recapture = "gut hooked";                             //recommended
     string :fate_recapture = "harvested";                                   //recommended
     string :lifestage_recapture = "adult";                                  //recommended
     string :tag_placement = "body cavity";                                  //recommended
     double :hours_soaktime_capture = 0.1f;                                  //optional
```

```
  double :hours_soaktime_recapture = 1.5f;                                  //optional
  integer:implant_numsuture = 3;                                            //optional
  double :minutes_operation = 0.5f;                                         //optional
  double :minutes_revival = 1.0f;                                           //optional
  string :sex = "unknown";                                                  //optional
  string :stock = "unknown";                                                //optional
  string :tissue_sample_capture = "Blood-ID02101";                          //optional
  string :tissue_sample_recapture = "Blood-ID02102";                        //optional
  string :weight_type_capture = "whole";                                    //optional
  string :weight_method_capture = "measured";                               //optional
  double :weight_capture = 1200.0f;                                         //optional
  string :weight_unit_capture = "g";                                        //optional
  string :weight_type_recapture = "dressed";                                //optional
  string :weight_method_recapture = "measured";                             //optional
  double :weight_recapture = 2700.0f;                                       //optional
  string :weight_unit_recapture = "g";                                      //optional
  }

group: attachment {
  string :attachment_method = "anchor";                                     //REQUIRED
  string :anesthetic_product = "metomidate";                                //optional
  string :antifouling_product = " Micron66";                                //optional
  }

group: ancillary_positions {
  string :ancillary_position_source = "Acoustic detections";                //optional
  string :ancillary_position_instrumentid = "receiverID1003, receiverID1008,
                                            receiverID1121";                //optional
  string :datetime_ancillary_position = "2016-01-04 22:32:21, 2016-02-01 02:41:11,
                                            2016-03-29 09:15:31";           //optional
  string :ancillary_position_lon = "-153.42,-152.42,-152.49";               //optional
  string :ancillary_position_lat = "42.131,41.135,42.422";                  //optional
  string :ancillary_position_quality = " LC0,LC1,LCA";                      //optional
  }

group: deployment {
  string :time_coverage_start = "2005-04-15";                               //REQUIRED
  double :geospatial_lon_start = -95.18f;                                   //REQUIRED
  double :geospatial_lat_start = -1.94f;                                    //REQUIRED
  string :person_tagger_capture = "D. Fuller";                              //REQUIRED
  string :location_capture = "Catalina Island";                             //recommended
  string :method_capture = "longline";                                      //recommended
  string :baitlure_capture = "sardine";                                     //optional
  string :cruise_capture = "SPURS2";                                        //optional
  double :depth_m_capture = 10.0f;                                          //optional
  string :flag_capture = "USA";                                             //optional
  string :hook_capture = "18/0 circle";                                     //optional
  string :method_aboard = "net";                                            //optional
  string :othertags_capture = "Hallprint PAR007007";                        //optional
  string :person_angler_capture = "D. Fuller";                              //optional
  string :school_capture = "FAD";                                           //optional
  string :seastate_capture = "rough";                                       //optional
  string :set_float_capture = "10";                                         //optional
```

```
  string :station_capture = "TAO-10";                                    //optional
  double :temp_degC_capture = 13.5f;                                     //optional
  string :vessel_capture = "R/V Endeavor";                               //optional
  double :wind_knots_capture = 8.3f;                                     //optional
  }

group: end_of_mission {
  string :time_coverage_end = "2009-07-02";                              //REQUIRED
  string :geospatial_lon_end = -83.98f;                                  //REQUIRED
  string :geospatial_lat_end = -1.45f;                                   //REQUIRED
  string :end_details = "recovered by fishing fleet";                    //REQUIRED
  string :end_type = "recaptured";                                       //REQUIRED
  string :locationclass_end = "2";                                       //recommended
  string :datetime_death = "2017-07-11T18:24:23+00:00";                  //optional
  }

group: instrument {
  string :instrument_name = "16P0100-Refurb2";                           //REQUIRED
  string :instrument_type = "archival";                                  //REQUIRED
  string :firmware = "1235";                                             //REQUIRED
  string :manufacturer = "Wildlife Computers";                           //REQUIRED
  string :model = "Mk 9";                                                //REQUIRED
  string :person_owner = "Kurt Schaefer";                                //REQUIRED
  string :owner_contact = "kschaefer@iattc.org";                         //REQUIRED
  string :serial_number = "590051";                                      //REQUIRED
  string :date_shipment = "2017-07-11T18:24:23+00:00";                   //recommended
  string :project = "SPURS2";                                            //recommended
  string :specs = "Manufacturer WC- MK9model URI";                       //recommended
  }

group: programming {
  string :programming_report = "URI to report";                          //REQUIRED
  string :programming_software = "WC-prg-v3";                            //REQUIRED
  string :date_programming = "2008-11-02";                               //REQUIRED
  integer :days_mission = 365;                                           //recommended
  integer :minutes_summary = 1440";                                      //recommended
  string :person_programmer = "Kurt Schaefer";                           //recommended
  integer :seconds_sampling = 15;                                        //recommended
  integer :seconds_writingdata = 300;                                    //recommended
  integer :seconds_sampling_highfreq = 100;                              //optional
  }

group: quality {
  string :found_problem = "no";                                          //REQUIRED
  string :person_qc = "Dan Fuller";                                      //REQUIRED
  string :problem_affecteddates = "2008-10-02 to 2008-11-30";            //recommended
  string :problem_details = "Daily drift after sunset by 1.5 degC";      //recommended
  integer:problem_numof = 1;                                             //recommended
  string :problem_summary = "Temperature sensor drift";                  //recommended
  string :calibration_file = "URL to sensor calibration document";       //optional
  }
```

```
  group: recovery {
    string :location_recapture = "San Pedro Channel";                       //recommended
    string :method_recapture = "longline";                                  //recommended
    string :person_recapture = "Kurt Schaefer";                             //recommended
    string :baitlure_recapture = "sardine";                                 //optional
    string :cruise_recapture = "Spurs3";                                    //optional
    double :depth_m_recapture = 10.0f;                                      //optional
    string :flag_recapture = "Chile";                                       //optional
    string :hook_recapture = "18/0 Circle";                                 //optional
    string :person_tagger_recapture = "Kurt Schaefer";                      //optional
    string :retagged_recapture = "Hallprint PAR007007";                     //optional
    string :school_recapture = "FAD";                                       //optional
    string :seastate_recapture = "calm";                                    //optional
    string :set_float_recapture = "160";                                    //optional
    string :station_recapture = "TAO-12";                                   //optional
    double :temp_degC_recapture = 12.6f;                                    //optional
    string :vessel_recapture = "R/V Gamboa";                                //optional
    double :wind_knots_recapture = 6f;                                      //optional
    }

  group: waypoints {
    string :waypoints_source = "modeled";                                   //REQUIRED
    string :waypoints_method = "ukfsst";                                    //recommended
    string :geolocation_parameters = "diffusion_coefficien:0.3, MUR-SST";   //recommended
    string :interpolation_method = "crawl";                                 //recommended
    string :interpolation_time = "gap filling";                             //recommended
    string :waypoints_software = "UKFSST_v3";                               //recommended
    string :geolocation_output = ftp://myserver/myfiles.zip;                //optional
    }
  }
}
```

Transmitted Summary Tag Data Template

nc-eTAG_PSATsummarydata_Template.cdl

This nc-eTAG (PSAT-summary) template applies to popup satellite archival (PSAT) transmitted summary datasets. The specifications provides support for both:

- bin-frequency type data representations (eg. time series of temperature and depth distribution data for pre-programmed, fixed intervals)
- data range summaries for dynamically defined/varying intervals over time. These are typical of electronic tag PDT output representations.

Note also that this template in part can also be applied to satellite positional tag datasets (eg. SPOT, GPS) that just record location information. For those datasets, only the global attribute and coordinate variable blocks will apply; additionally, applicable dimensions would be limited to *time* and *str_len*.

```
netcdf file\:/C\:/ nc-eTAG_PSATsummarydata_Template {
  dimensions:
    time = 1000;
    bins_freq = 14;
    bins_pdt = 8;
    bnds =2;
    str_len = 6;

  variables:

  //Coordinate and Auxiliary Coordinate Variables

   char trajectory(str_len);
      string :cf_role = "trajectory_id";

   double time(time);
      string time:long_name = "Time of observation interval";
      string time:standard_name = "time";
      string time:units = "seconds since 1970-01-01T00:00:00";  // UTC
      string time:axis = "T";
      string time:bounds = “time_bnds”;
      string time:coverage_content_type = "coordinate";

   double time_bnds(time, bnds);

   double location_freshness(time);
      string location_freshness:long_name = "location_freshness";
      string location_freshness:comment = "time since last latitude and longitude
                                          observations";
      string location_freshness:units = "seconds";
      double location_freshness:_FillValue = -999999;
      double location_freshness:valid_max = 86340.0;
      double location_freshness:valid_min = 0.0;
      string location_freshness:coverage_content_type = "auxiliaryInformation";
```

```
double longitude(time);
   string longitude:long_name = "estimated longitude";
   string longitude:standard_name = "longitude";
   string longitude:units = "degrees_east";
   string longitude:axis = "X";
   double longitude:_FillValue = -999999;
   double longitude:valid_max = -118.48636166666667;
   double longitude:valid_min = -127.43765333333333;
   string longitude:ancillary_variables = "longitude_uncertainty";
   string longitude:coverage_content_type = "coordinate";

double longitude_uncertainty(time);
   string longitude_uncertainty:long_name = "derived uncertainty around longitude
                                                estimate";
   string longitude_uncertainty:standard_name = "longitude standard_error";
   string longitude_uncertainty:units = "degrees";
   double longitude_uncertainty:_FillValue = -999999;
   double longitude_uncertainty:valid_max = 0.05;
   double longitude_uncertainty:valid_min = 0.01;
   string longitude_uncertainty:coverage_content_type = "qualityInformation";

double latitude(time);
   string latitude:long_name = "estimated latitude";
   string latitude:standard_name = "latitude";
   string latitude:units = "degrees_north";
   string latitude:axis = "Y";
   double latitude:_FillValue = -999999;
   double latitude:valid_max = 30.639526666666665;
   double latitude:valid_min = 9.908965;
   string latitude:ancillary_variables = "latitude_uncertainty";
   string latitude:coverage_content_type = "coordinate";

double latitude_uncertainty(time);
   string latitude_uncertainty:long_name = "derived uncertainty around latitude estimate";
   string latitude_uncertainty:standard_name = "latitude standard_error";
   string latitude_uncertainty:units = "degrees";
   double latitude_uncertainty:_FillValue = -999999;
   double latitude_uncertainty:valid_max = 0.05;
   double latitude_uncertainty:valid_min = 0.01;
   string latitude_uncertainty:coverage_content_type = "qualityInformation";

 char argosLC_qc(time);
   string argosLC_qc:long_name = "ARGOS location class geolocation quality code";
   string argosLC_qc:standard_name = "quality_flag";
   string argosLC_qc:_FillValue = "9";
   string argosLC_qc:flag_values = “G, 3, 2, 1, 0, A, B, Z”;
   string argosLC_qc:flag_meanings = "<100 <250m 250-500m 500-1500m >1500m
                           unestimated3messages unestimated2messages invalidlocations";
   string argosLC_qc:comment = "Argos location error/quality codes from  http://www.argos-
                                system.org/manual/3-location/34 location classes.htm"
   string argosLC_qc:coverage_content_type = "qualityInformation";
```

```
double depth (bins_freq);
   string depth:long_name = "depth interval lower bound";
   string depth:standard_name = "depth";
   string depth:units = "m";
   string depth:axis = "Z";
   string depth:positive = "down";
   double depth:valid_max = 500.000;
   double depth:valid_min = 0.000;
   string depth:bounds = “depth_bnds”;
   string depth:coverage_content_type = "coordinate";
   string depth:comment = "lower bounds of programmed PAT depth intervals used in
                           transmitted daily summary bin-depth data";

double depth_bnds (bins_freq, bnds);

double temperature (bins_freq);
   string temperature:long_name = "temperature interval lower bound";
   string temperature:standard_name = "temperature";
   string temperature:units = "degrees_C";
   double temperature:valid_max = 20.0;
   double temperature:valid_min = 10.0;
   string temperature:bounds = “temperature_bnds”;
   double temperature:coverage_content_type = "coordinate";
   string temperature:comment = "lower bounds of programmed PAT temperature intervals used
                                 in transmitted daily summary bin-temperature data";

double temperature_bnds (bins_freq, bnds);

double  PDTdepth (time, bins_pdt);
   string PDTdepth:long_name = "dynamic depth interval lower bound";
   string PDTdepth:standard_name = "depth";
   string PDTdepth:units = "m";
   string PDTdepth:axis = "Z";
   string PDTdepth:positive = "down";
   double PDTdepth:valid_max = 500.0;
   double PDTdepth:valid_min = 0.0;
   string PDTdepth:bounds = “PDTdepth_bnds”;
   string PDTdepth:coverage_content_type = "coordinate";
   string PDTdepth:comment = "lower bounds of PAT dynamic PDT depth intervals used in
                                 transmitted daily summary data";

double PDTdepth_bnds (time, bins_pdt, bnds);

//Geophysical measurement Variables

double depth_frequency(time, bins_freq);
   string depth_frequency:long_name = "Percentage time spent at a given pre-programmed
                                       depth interval";
   string depth_frequency:units = "%";
   double depth_frequency:_FillValue = -999999;
   double depth_frequency:valid_max = 100.0;
   double depth_frequency:valid_min = 0.0;
   string depth_frequency:cell_methods = “time : depth : count”;
```

```
    string depth_frequency:coordinates = "time latitude longitude depth trajectory";
    string depth_frequency:coverage_content_type = "physicalMeasurement";

 double temperature_frequency(time, bins_freq);
    string temperature_frequency:long_name = "Percentage time spent at a given pre-
                                             programmed temperature interval";
    string temperature_frequency:units = "%";
    double temperature_frequency:_FillValue = -999999;
    double temperature_frequency:valid_max = 100.0;
    double temperature_frequency:valid_min = 0.0;
    string temperature_frequency:cell_methods = “time : temperature : count”;
    string temperature_frequency:coordinates = "time latitude longitude temperature
                                             trajectory";
    string temperature_frequency:coverage_content_type = "physicalMeasurement";

 double PDTtemperature_Min(time, bins_pdt);
    string PDTtemperature_Min:long_name = "Minimum temperatures at dynamic depth intervals";
    string PDTtemperature_Min:units = "degrees_C";
    double PDTtemperature_Min:_FillValue = -999999;
    double PDTtemperature_Min:valid_max = 32.0;
    double PDTtemperature_Min:valid_min = -2.0;
    string PDTtemperature_Min:cell_methods = “time : depth : min”;
    string PDTtemperature_Min:coordinates = "time latitude longitude PDTdepth trajectory";
    string PDTtemperature_Min:coverage_content_type = "physicalMeasurement";
    string PDTtemperature_Min:comment = "Minimum temperatures over time for PAT dynamic PDT
                                  depth intervals in transmitted daily summary data";

 double PDTtemperature_Max(time, bins_pdt);
    string PDTtemperature_Max:long_name = "Maximum temperatures at dynamic depth intervals";
    string PDTtemperature_Max:units = "degrees_C";
    double PDTtemperature_Max:_FillValue = -999999;
    double PDTtemperature_Max:valid_max = 32.0;
    double PDTtemperature_Max:valid_min = -2.0;
    string PDTtemperature_Max:cell_methods = “time : depth : max”;
    string PDTtemperature_Max:coordinates = "time latitude longitude PDTdepth trajectory";
    string PDTtemperature_Max:coverage_content_type = "physicalMeasurement";
    string PDTtemperature_Max:comment = "Maximum temperatures over time for PAT dynamic PDT
                                  depth intervals in transmitted daily summary data";

// Global attributes:
  // CF-ACDD global attributes

  string :Conventions = "CF-1.7, ACDD 1.3, COARDS";
  string :Metadata_Conventions = "Unidata Dataset Discovery v1.3";
  string :featureType = "trajectory";
  string :cdm_data_type = "Trajectory";
  string :nodc_template_version = "NODC_NetCDF_Trajectory_Template_v2.0, ATN extension";
  string :standard_name_vocabulary = "CF Standard Name Table v27";
  string :title = "Animal telemetry archival tag netCDF template";
  string :source = "atn.noaa.gov";
  string :platform = "Thunnus obesus";
  string :instrument = "Wildlife Computers MK9";
  string :uuid = "70e37fb7-da57-4dee-81f4-f965a3c08762";
```

```
string :id = "10.5067/ATN_00001";   // Dataset DOI
string :metadata_link = "https://atn.noaa.gov/dataset/ATN_00001"
string :references = "Fuller, Daniel & Schaefer, Kurt & Hampton, John & Caillot, Sylvain &
                  Leroy, Bruno & Itano, David. (2015). Vertical movements, behavior, and
                  habitat of bigeye tuna (Thunnus obesus) in the equatorial central
                  Pacific Ocean. Fisheries Research. 172. 57-70.
                  10.1016/j.fishres.2015.06.024.";
string :sea_name = "Pacific";
string :naming_authority = "gov.noaa.gov.atn";
string :time_coverage_start = "2014-08-07T07:33:30";
string :time_coverage_end = "2014-08-31T00:00:00";
string :time_coverage_resolution = "PT1D";  //alter to reflect the time interval of data
double :geospatial_lat_min = 9.908965;
double :geospatial_lat_max = 30.639526666666665;
string :geospatial_lat_units = "degrees_north";
string :geospatial_lat_resolution = "0.1 degree";
double :geospatial_lon_min = -127.43765333333333;
double :geospatial_lon_max = -118.48636166666667;
string :geospatial_lon_units = "degrees_east";
string :geospatial_lon_resolution = "0.1 degree";
double :geospatial_vertical_min = 500.000;
double :geospatial_vertical_max = 0.000;
string: geospatial_vertical_units = "m";
string: geospatial_vertical_resolution = "10 meters";
string :creator_type = "institution";
string :creator_institution = "Inter-American Tropical Tuna Commission (IATTC)";
string :creator_email = "kschaefer@iattc.org";
string :creator_name = "Schaefer, Kurt";
string :creator_role = "Researcher";
string :institution = "Inter-American Tropical Tuna Commission (IATTC)";
string :publisher_name = "Vardis Tsontos";
string :publisher_type = "person";
string :publisher_email = "vtsontos@jpl.nasa.gov";
string :publisher_url = "https://podaac.jpl.nasa.gov/";
string :project = "IATTC Bigeye tuna behavior program";
string :processing_level = "Level 2";
string :keywords_vocabulary = "CF Standard Names, GCMD Science Keywords";
string :keywords = "Temperature, electronic tag, animal telemetry, bigeye, tuna, Thunnus
                        obesus, IATTC, Eastern Tropical Pacific Ocean";
string :acknowledgement = "Funding provided by IATTC under grant 2019-XYZ.";
string :date_created = "2019-09-18T13:53:21";
string :date_modified = "2019-09-18T13:53:21";
string :date_issued = "2019-09-18T13:53:21";
string :date_metadata_modified = "2019-09-18T13:53:21";
string :program = "IATTC Tuna Behavior and Life History";
string :product_version = "1.0";
string :license = "IATTC data are copyrighted and available publicly on condition of
                  institution and researcher citation.";
string :summary = "PSAT tag dataset showing the migration and diving
                  patterns of an adult Bigeye tuna in the Eastern Tropical Pacific
                  courtesy of Kurt Schaeffer and Dann Fuller of the IATTC";
```

```
// Animal Telemetry domain global attributes organized by category in Group structures

group: Meta_eTag {
   group: animal {
     string :platformUUID = "123e4567-e89b-12d3-a456-426655440000";          //REQUIRED
     string :platform = "Thunnus obesus";                                    //REQUIRED
     string :taxonomic_serial_number = "172428";                             //REQUIRED
     string :length_type_capture = "Straight fork length";                   //REQUIRED
     string :length_method_capture = "measured caliper";                     //REQUIRED
     double :length_capture = 67.0f;                                         //REQUIRED
     string :length_unit_capture = "cm";                                     //REQUIRED
     string :condition_capture = "good";                                     //REQUIRED
     string :lifestage_capture = "juvenile";                                 //recommended
     string :length_type_recapture = "Straight fork length";                 //recommended
     string :length_method_recapture = "predicted";                          //recommended
     double :length_recapture = 159.0f;                                      //recommended
     string :length_unit_recapture = "cm";                                   //recommended
     string :condition_recapture = "gut hooked";                             //recommended
     string :fate_recapture = "harvested";                                   //recommended
     string :lifestage_recapture = "adult";                                  //recommended
     string :tag_placement = "second dorsal fin";                            //recommended
     double :hours_soaktime_capture = 0.1f;                                  //optional
     double :hours_soaktime_recapture = 1.5f;                                //optional
     integer :implant_numsuture = 3;                                         //optional
     double :minutes_fighttime_capture = 13.0f;                              //optional
     double :minutes_fighttime_recapture = 25.0f;                            //optional
     double :minutes_operation = 0.5f;                                       //optional
     double :minutes_revival = 1.0f;                                         //optional
     string :sex = "unknown";                                                //optional
     string :stock = "unknown";                                              //optional
     string :tissue_sample_capture = "Blood-ID02101";                        //optional
     string :tissue_sample_recapture = "Blood-ID02102";                      //optional
     string :weight_type_capture = "whole";                                  //optional
     string :weight_method_capture = "measured";                             //optional
     double :weight_capture = 1200.0f;                                       //optional
     string :weight_unit_capture = "g";                                      //optional
     string :weight_type_recapture = "dressed";                              //optional
     string :weight_method_recapture = "measured";                           //optional
     double :weight_recapture = 2700.0f;                                     //optional
     string :weight_unit_recapture = "g";                                    //optional
     }

   group: attachment {
     string :attachment_method = "anchor";                                   //REQUIRED
     double :anchor_depth_cm = 8.0f;                                         //recommended
     string :anchor_dimensions_mm = “20 L x 14 W“                            //recommended
     string :anchor_material = “nylon“                                       //recommended
     string :attachment_product = “VetBond“                                  //recommended
     string :mount_type = “fin“                                              //recommended
     string :release_method = “corrosive burn wire“                          //recommended
     string :tether_assembly = “heat-shrink“                                 //recommended
     double :tether_length_cm = 10.0f;                                       //recommended
     string :tether_material = “monofilament“                                //recommended
```

```
  string :anesthetic_product = "metomidate";                                  //optional
  string :antifouling_product = " Micron66";                                  //optional
  string :antiseptic_product = "Iodine";                                      //optional
  string :float_additional = "no";                                            //optional
  string :release_forced = "no";                                              //optional
  }

group: ancillary_positions {
  string :ancillary_position_source = "Acoustic detections";                  //optional
  string :ancillary_position_instrumentid = "receiverID1003, receiverID1008,
                                            receiverID1121";                  //optional

  string :datetime_ancillary_position = "2016-01-04 22:32:21, 2016-02-01 02:41:11,
                                          2016-03-29 09:15:31";               //optional
  string :ancillary_position_lon = "-153.42,-152.42,-152.49";                 //optional
  string :ancillary_position_lat = "42.131,41.135,42.422";                    //optional
  string :ancillary_position_quality = "LC0,LC1,LCA";                         //optional
  }

group: deployment {
  string :time_coverage_start = "2005-04-15";                                 //REQUIRED
  double :geospatial_lon_start = -95.18f;                                     //REQUIRED
  double :geospatial_lat_start = -1.94f;                                      //REQUIRED
  string :person_tagger_capture = "D. Fuller";                                //REQUIRED
  string :location_capture = "Catalina Island";                               //recommended
  string :method_capture = "longline";                                        //recommended
  string :baitlure_capture = "sardine";                                       //optional
  string :cruise_capture = "SPURS2";                                          //optional
  double :depth_m_capture = 10.0f;                                            //optional
  string :flag_capture = "USA";                                               //optional
  string :hook_capture = "18/0 circle";                                       //optional
  string :method_aboard = "net";                                              //optional
  string :othertags_capture = "Hallprint PAR007007";                          //optional
  string :person_angler_capture = "D. Fuller";                                //optional
  string :school_capture = "FAD";                                             //optional
  string :seastate_capture = "rough";                                         //optional
  string :set_float_capture = "10";                                           //optional
  string :station_capture = "TAO-10";                                         //optional
  double :temp_degC_capture = 13.5f;                                          //optional
  string :vessel_capture = "R/V Endeavor";                                    //optional
  double :wind_knots_capture = 8.3f;                                          //optional
  }

group: end_of_mission {
  string :time_coverage_end = "2009-07-02";                                   //REQUIRED
  string :geospatial_lon_end = -83.98f;                                       //REQUIRED
  string :geospatial_lat_end = -1.45f;                                        //REQUIRED
  string :end_details = "recovered by fishing fleet";                         //REQUIRED
  string :end_type = "recaptured";                                            //REQUIRED
  string :locationclass_end = "2";                                            //recommended
  string :datetime_death = "2017-07-11T18:24:23+00:00";                       //optional
  }
```

```
group: instrument {
  string :instrument_name = "16P0100-Refurb2";                          //REQUIRED
  string :instrument_type = "archival";                                 //REQUIRED
  string :firmware = "1235";                                            //REQUIRED
  string :manufacturer = "Wildlife Computers";                          //REQUIRED
  string :model = "Mk 9";                                               //REQUIRED
  string :person_owner = "Kurt Schaefer";                               //REQUIRED
  string :owner_contact = "kschaefer@iattc.org";                        //REQUIRED
  string :serial_number = "590051";                                     //REQUIRED
  string :date_shipment = "2017-07-11T18:24:23+00:00";                  //recommended
  string :project = "SPURS2";                                           //recommended
  string :ptt = "1023456";                                              //recommended
  string :ptt_hex = "&#8217";                                           //recommended
  string :specs = "Manufacturer WC- MK9model URI";                      //recommended
  }

group: programming {
  string :programming_report = "URI to report";                         //REQUIRED
  string :programming_software = "WC-prg-v3";                           //REQUIRED
  string :date_programming = "2008-11-02";                              //REQUIRED
  integer: days_constantdepth = 1;                                      //recommended
  integer: days_mission = 365;                                          //recommended
  integer: minutes_summary = 1440";                                     //recommended
  string : person_programmer = "Kurt Schaefer";                         //recommended
  integer: seconds_sampling = 15;                                       //recommended
  integer: seconds_writingdata = 300;                                   //recommended
  integer: seconds_sampling_highfreq = 100;                             //optional
  }

group: quality {
  string :found_problem = "no";                                         //REQUIRED
  string :person_qc = "Dan Fuller";                                     //REQUIRED
  string :problem_affecteddates = "2008-10-02 to 2008-11-30";           //recommended
  string :problem_details = "Daily drift after sunset by 1.5 degC";     //recommended
  integer :problem_numof = 1;                                           //recommended
  string :problem_summary = "Temperature sensor drift";                 //recommended
  string :calibration_file = "URL to sensor calibration document";      //optional
  }

group: recovery {
  string :location_recapture = "San Pedro Channel";                     //recommended
  string :method_recapture = "longline";                                //recommended
  string :person_recapture = "Kurt Schaefer";                           //recommended
  string :baitlure_recapture = "sardine";                               //optional
  string :cruise_recapture = "Spurs3";                                  //optional
  double :depth_m_recapture = 10.0f;                                    //optional
  string :flag_recapture = "Chile";                                     //optional
  string :hook_recapture = "18/0 Circle";                               //optional
  string :person_tagger_recapture = "Kurt Schaefer";                    //optional
  string :retagged_recapture = "Hallprint PAR007007";                   //optional
  string :school_recapture = "FAD";                                     //optional
  string :seastate_recapture = "calm";                                  //optional
  string :set_float_recapture = "160";                                  //optional
```

```
    string :station_recapture = "TAO-12";                                    //optional
    double :temp_degC_recapture = 12.6f;                                     //optional
    string :vessel_recapture = "R/V Gamboa";                                 //optional
    double :wind_knots_recapture = 6f;                                       //optional
    }

  group: waypoints {
    string :waypoints_source = "modeled";                                    //REQUIRED
    string :waypoints_method = "ukfsst";                                     //recommended
    string :geolocation_parameters = "diffusion_coefficien:0.3, MUR-SST";    //recommended
    string :interpolation_method = "crawl";                                  //recommended
    string :interpolation_time = "gap filling";                              //recommended
    string :waypoints_software = "UKFSST_v3";                                //recommended
    string :geolocation_output = ftp://myserver/myfiles.zip;                 //optional
    }
  }
}
```

4 Group Metadata Structures

The nc-eTAG templates take advantage of hierarchical “Group” structures already supported by the netCDF Enhanced Data Model and integral to the proposed and now accepted Group extension to the CF standards [11], which should be part of the next release. Currently in the nc-eTAG specification, Groups are used/reserved only for systematically organizing rich sets of categorized tagging domain metadata attributes. To insure compatibility with existing tools and services based on current CF standards, the set of typical CF and ACDD metadata attributes are listed simply in the global attributes block and not associated with Group structures of their own. This is shown in the CDL pseudo-code below.

```
// Global attributes:
    // CF-ACDD global attributes
       cf_attribute1
       ...
       cf_attributeN
       acdd_attribute1
       ...
       acdd_attributeN

    // Animal Telemetry domain global attributes organized by category in Group structures
       group: Meta_eTag {
           group: animal {...}
           group: ancillary_positions {...}
           group: attachment {...}
           group: deployment {...}
           group: end_of_mission {...}
           group: instrument {...}
           group: programming {...}
           group: quality {...}
           group: recovery {...}
           group: waypoints {...}
       }
```

Upon the next release of the CF standards, encapsulation of the CF and ACDD attributes within Groups of their own within the file global file metadata block is recommended [2]. The approach is illustrated in the CDL below.

```
// Global attributes:
    // CF-ACDD global attributes organized by type in Group structures
       group: cf {...}
       group: acdd {...}

    // Animal Telemetry domain global attributes organized by category in Group structures
       group: Meta_eTag {
           group: animal {...}
           …
           group: waypoints {...}
       }
```

5 Multiple Tag Support

For simplicity, we generally recommend that a single netCDF data file be used for the storage of instrument data and associated metadata from a single electronic tag deployment. However, the CF data model and advent of Groups do potentially allow for the packaging of multiple “features” or tag datasets and all associated rich metadata within a single netCDF data file in an elegant way. The approach is briefly described here.

An additional dimension representing the total number of features/trajectories needs to be declared. This is used to dimension tag data and coordinate variable arrays to distinguish observations associated with different tag deployments.

```
dimensions:
    time = 1000;
    trajectory = 7;         //added feature dimension. File will support tag data from 7
                                    deployments
    ..
```

All variable arrays (types: identifier, coordinate, measurement) need to be additionally dimensioned by *trajectory* when data from multiple trajectory features/tag deployments are packaged in a single netCDF file. This is illustrated below for that Archival tag case. The approach would be comparable for the other two template types as well.

```
  variables:
    char trajectory(trajectory, str_len);              // Feature identifier variable
    double time(trajectory, trajectory, time);         // Coordinate & auxiliary
                                                              coordinate variables
    double location_freshness(trajectory, time);
    double longitude(trajectory, time);
    double longitude_uncertainty(trajectory, time);
    double latitude(trajectory, time);
    double latitude_uncertainty(trajectory, time);
    double depth(trajectory, time);
    double external_temperature(trajectory, time);     // Geophysical measurement
                                                              variables
    double internal_temperature(trajectory, time);
    double illuminance(trajectory, time);
```

The feature variable name identifier (trajectory) would additionally need to be declared in the coordinate attribute of all file measurement variables as illustrated below for one such variable:

```
double external_temperature(trajectory, time);
       …
       string internal_temperature:coordinates = "time latitude longitude depth
                                                  trajectory";
```

Support for detailed metadata associated with each of the multiple tag deployment features (trajectories) packaged in the file is possible by extensions further leveraging the use of Groups to hierarchically store blocks of logically organized attributes by feature/trajectory, with subgroups containing the CF, ACDD, and 10 categories of electronic tag metadata attributes. This is illustrated in the CDL pseudo-code below.

```
// Global attributes:
    group: Meta_eTag_1 {                  // Metadata Group & subgroups for first eTag
                                                Feature/Trajectory
       group: cf {...}                    // CF-ACDD attribute Group structures
       group: acdd {...}
       group: Meta_eTag {                 // Animal Telemetry attribute Group structures
          group: animal {...}
          …
          group: waypoints {...}
          }
       }
…
    group: Meta_eTag_7 {                  // Metadata Group & subgroups for last eTag
                                                Feature/Trajectory
       group: cf {...}                    // CF-ACDD attribute Group structures
       group: acdd {...}
       group: Meta_eTag {                 // Animal Telemetry attribute Group structures
          group: animal {...}
          …
          group: waypoints {...}
          }
       }
```

6 Implementation Recommendations

This document focuses on the specification of the nc-eTAG template standards rather than details of the implementation of the CDL templates. However, some recommendations on key aspects of implementation relating to optimization of output files produced are highlighted briefly here. Note that beyond groups and chunking/compression, new features enabled by the Enhanced Data Model and the netCDF-4 file format that are not explicitly described by the CF conventions are generally not recommended at this time.

Compression

An important feature of the netCDF-4 file format is that it natively supports internal compression of binary file data in chunks that can be flexibly defined upon write thanks to the use of HDF-5 as the storage format. [9]. This promotes generation of compact files that are substantially smaller in size than uncompressed versions. Notably, it concomitantly allows portions of file data being read to be uncompressed and accessed dynamically/efficiently on demand without the performance hit of first having to uncompress the entire file before data reads can occur. The netCDF-4 file format's internal compression also allows file global metadata to be read independently without need for uncompressing any data blocks. Given these advantages, we recommend that internal file compression be generally used when implementing the nc-eTAG templates with the netCDF-4 file format. It is particularly important to do so when dealing with larger datasets (eg. longer deployments of higher frequency data involving multiple variable fields) and in situations where multiple tag datasets are packaged in the same file.

Advanced Data Arrays

NetCDF provides support for multi-dimensional data arrays that are both uniform in extent or comprised of variable length data vectors along any given dimension. The latter situation would arise if data from multiple tags, each of different deployment duration, were to be packaged in the same file. While as previously stated our recommendation is to store data from each tag in a separate data file, here we briefly describe the pros and cons to implementations for multi-tag support involving both conventional and more advanced data storage options provided by netCDF and the CF standards.

The conventional (and simplest) approach would be to store the tag data in array structures of uniform length, dimensioned also by the number of features (tag deployments/trajectories) comprising the particular dataset. The result would be a set of multi-dimensional arrays that would be fill-value padded where necessary to produce complete matrices of values, homogeneous in extent and regular in structure. Despite such fill padding, a compact data file could nonetheless be produced if implemented in netCDF-4 with internal compression. This follows because data compression operates particular efficiently in situations such as the above where there are contiguous blocks of data with identical (fill) values. Such a compact, standards compliant data file could also be read and processed without difficulty by a wide range of existing client software without these needing any advanced capabilities for handling variable length arrays. This is the approach we, therefore, strongly recommend in situations when data from multiple tags need to stored in a single file.

However, for situations where data volumes are significant and storage optimization is critical, the CF conventions do provide specifications for the packaging of multi-dimensional data as variable length vectors using what are referred to as "Ragged Arrays". It is beyond the scope here to describe either such "continuous" or "indexed" ragged array implementations. The reader instead should consult the CF documentation for details [6]. Both NetCDF-3 and the netCDF-4 Classic files support continuous and indexed ragged arrays. However, a consequence of these advanced data structures is that the availability of client software capable of robustly handling these more complicated, albeit CF-compliant, data files will

be limited. The netCDF-4 Enhanced Data Model and associated software libraries do provide support for variable length arrays (VLEN) [10] that considerably simplify the reading and writing of ragged arrays. However, VLEN has yet to be adopted in the CF conventions, so technically a netCDF-4 file utilizing arrays of type VLEN to package data from multiple electronic tags would not be CF-compliant. Furthermore, the availability of client software tools capable of working with VLEN data structures at this time is limited. These reasons further reinforce our prior recommendation above: that the simplest approach, involving the application of netCDF-4 compression on regular multidimensional arrays, be applied in cases where data from multiple tag series need to be packaged in a single file. Again, storage of data from one electronic tag in a single netCDF-4 data file using the Enhanced Data Model should generally be the preferred implementation.

7 References

[1] OIIP (2017). NCEI netCDF Template Review for Electronic Tag Data Support. NASA/JPL. 20p. https://doi.org/10.6084/m9.figshare.10032863.v2

[2] OIIP (2017). Tag Metadata Review & Recommendations Document. NASA/JPL. 30p. https://doi.org/10.6084/m9.figshare.10032848.v3

[3] NSF EarthCube sponsored “Advancing netCDF-CF” project (commonly referred to as “CF 2.0”)

[4] netCDF Common Data Language (CDL). UCAR/Unidata.

[5] netCDF Enhanced Data Model. UCAR/Unidata.

[6] CF Climate Forecast Conventions v1.7. CFconventions.org.

[7] CF Climate Forecast Convention Standards Name v68. CFconventions.org.

[8] ACDD Attribute Conventions for Data Discovery. UCAR/Unidata & ESIP-Federation.

[9] NCEI netCDF in-situ Oceanographic Data Templates. NOAA/NCEI.

[10] netCDF 4.0 Users Guide (NUG) documentation. UCAR/Unidata.

[11] Support for Groups in the Climate Forecast standards. CF-conventions.

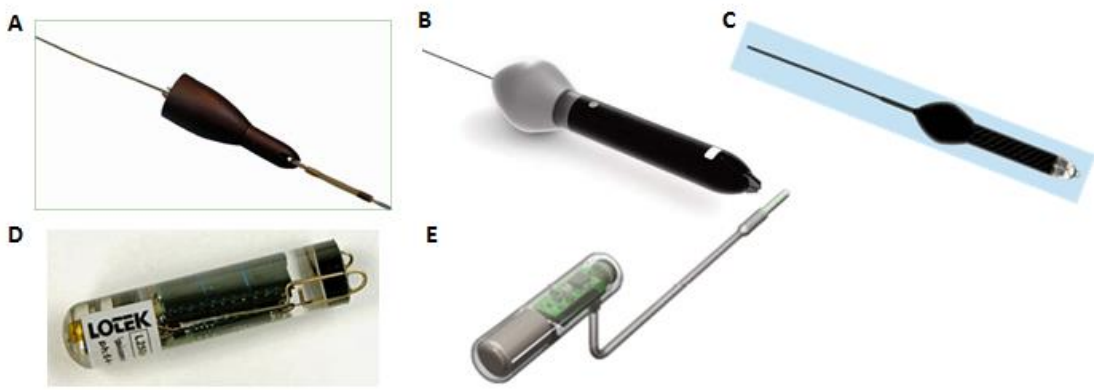
Appendix

eTag Types

Non-acoustic, electronic archival tagging data of relevance that are the focus of the OIIP project are comprised of two basic types:

- Continuous time series of sensor observations from implanted archival tags that are retrieved upon recapture of the tagged animal (figure 1 D-E) or from physically retrieved PSAT tags (figure 1A-C) that have popped off the animal.
- Summary data transmitted to satellite from retrieved Pop-up Satellite Archival (PSAT) upon release from the animal.

Figure 1. Electronic tag types illustrated. Popup Satellite Archival (PSAT) tags (A-C) and implantable Archival tags (D-E). A. LOTEK PSAT, B. Wildlife Computers PAT, D. LOTEK LAT2500, E. Wildlife Computers MK9



Native eTag Data Formats

Representative illustrations of archival and summarized popup (PSAT) data files from a range of models and manufacturers showing the typical contents and organization of associated electronic tag metadata and data are summarized below. Figures 2-5 show the typical contents and organization of electronic tag data files of different type, including metadata elements and columnar data.

Archival Data Formats

Excerpts of outputs from LOTEK, Wildlife Computers (WC), and Microwave Telemetry (MT) archival tag data files are shown in figures 2-4 respectively. Note that the upper part of each figure shows the structure of the archival sensor data whereas the lower portion of the figures illustrates associated light-based geolocation output from archival tags. Linkage of these horizontal position and vertical profile series is based on time stamp. However, it is important to note that the number of Lat/Lon positional estimates are

likely to be considerably less than available profile time series observational sensor data given the comparatively low frequency of available positional fixes.

Figure 2. LOTEK Archival Tag Data Files. [Top] Geophysical sensor, depth and time stamp columnar data . [Bottom] Light based geolocation data with mission day and associated daily summary geophysical data. Linkage between detailed archival geophysical values (light, internal body temperature, ambient water temperature, light level) at depth time series is via mission day fields.

Block Number	Mission Day	Second of Day	Depth - dBar	Light at Depth	Light at Surface	Light Too Dim	Int Temp deg C	Ext Temp deg C	Timestamp
0	0	82500	1	345	374.15	0	24.57	23.39	10/4/2002 22:55
0	0	82560	4	348	379.28	0	25.38	25.28	10/4/2002 22:56
0	0	82620	3	348	378.57	0	25.63	25.39	10/4/2002 22:57
0	0	82680	3	348	378.57	0	25.77	25.12	10/4/2002 22:58
0	0	82740	3	349	379.57	0	25.79	24.85	10/4/2002 22:59
0	0	82800	3	348	378.57	0	25.79	24.58	10/4/2002 23:00
0	0	82860	2	348	377.86	0	25.72	24.33	10/4/2002 23:01
0	0	82920	2	351	380.86	0	25.68	24.13	10/4/2002 23:02
0	0	82980	3	355	385.57	0	25.57	23.86	10/4/2002 23:03
0	0	83040	3	355	385.57	0	25.5	23.64	10/4/2002 23:04
0	0	83100	3	355	385.57	0	25.38	23.5	10/4/2002 23:05
0	0	83160	3	351	381.57	0	25.27	23.37	10/4/2002 23:06
0	0	83220	3	353	383.57	0	25.18	23.35	10/4/2002 23:07

Sunrise UT	Sunset UT	Longitude	Latitude	Noon Ligh	Night Ligh	SST Media	Depth For	Opacity - a	Opacity - b	Max Temp	Max Depth	Min Depth	Low Lim M	Time Seri	Mission D	Clock Adj	Battery Vo	Activity M	Condition	T S Pointer
16:05	0:00			393	0	25.28	4	0	0	25.39	4	-1	-1	1	0	0	3.231	40	255	0
0:00	23:41			0	0	94.18	4055	45.01	45.01	23.39	2	-1	-1	1	1	0	3.18	0	255	66
0:00	0:00			0	0	94.18	4055	45.01	45.01	23.21	3	-1	-1	1	2	0	3.178	0	255	1506
0:00	0:00			0	0	94.18	4055	45.01	45.01	23.73	2	-1	-1	0	3	0	3.178	40	255	-1
0:00	0:00			0	0	94.18	4055	45.01	45.01	26.44	3	-1	-1	1	4	0	3.2	40	255	4386
0:00	0:00			0	0	94.18	4055	45.01	45.01	28.92	3	-1	-1	0	5	0	3.13	40	255	-1
0:00	0:00			0	0	94.18	4055	45.01	45.01	20.95	1	-2	-2	1	6	0	3.129	0	255	7266
0:00	0:00			0	0	94.18	4055	45.01	45.01	22.35	2	-2	-2	0	7	0	3.151	0	255	-1
0:00	0:00			0	0	94.18	4055	45.01	45.01	24.56	2	-1	-1	1	8	0	3.169	0	255	10146
13:27	0:00			474	0	24.64	4	35.16	35.16	24.82	61	-1	-1	0	9	0	3.171	15	250	-1
13:19	1:18	-113.1	21.6	462	0	24	6	43.57	43.57	25.12	67	1	32	1	10	0	3.162	15	250	13026
13:21	1:17	-113.3	23	458	0	23.53	6	45.01	45.01	24.62	72	1	26	0	11	0	3.156	17	255	-1
13:22	1:16	-113.3	23.4	457	0	24.26	5	46.55	12.94	24.91	98	0	29	1	12	0	3.156	17	237	15906
13:21	1:19	-113.6	20.2	454	0	23.86	5	39.57	27.4	24.85	288	0	25	0	13	0	3.158	18	236	-1
13:25	1:15	-113.7	24.4	458	0	23.62	5	35.46	29.47	24.87	99	0	25	1	14	0	3.159	17	241	18786
13:22	1:12	-113	23.7	462	0	24.08	5	32.9	25.05	25.57	183	0	24	0	15	0	3.168	17	241	-1
13:23	1:12	-113.2	23.4	469	0	24.62	4	30.12	50.57	25.41	246	-1	14	1	16	0	3.135	18	233	21666
13:29	1:13	-114.1	25.5	445	0	23.06	5	51.52	22.08	24.06	108	0	28	0	17	0	3.133	17	242	-1
13:28	1:12	-113.9	24.8	446	0	23.91	4	50.88	30.01	23.95	117	-1	0	1	18	0	3.146	16	249	24546
13:26	1:09	-113.3	24.8	454	0	23.46	5	42.45	28.15	23.75	178	0	1	0	19	0	3.125	19	244	-1
13:29	1:09	-113.7	25.5	454	0	22.53	4	37.58	28.25	23.39	168	-1	38	1	20	0	3.138	18	245	27426

Figure 3. Wildlife Computers Archival Tag Data Files. [Top] Geophysical sensor data (light, internal body temperature, ambient water temperature, light level), depth and time stamp columnar data . [Bottom] Light based geolocation data with mission day and associated daily summary geophysical data. Linkage between detailed archival geophysical values at depth time series is via date/time fields.

	A	B	C	D	E
1	; SN 03900075				
2	; MK9 HW 1.3 SW 1.7.				
3	; Records 0 to 302422 of 789318				
4	Date	Depth	Recorder Temp	Stalk Temp	Light Level
5	38435.68	-1	24.3	23.05	137
6	38435.68	-1	25.15	22.35	126
7	38435.68	-1.5	24.9	21.7	126
8	38435.68	-1.5	24.45	21.45	125
9	38435.68	-0.5	24.1	22.05	140
10	38435.68	-0.5	23.95	22.5	142
11	38435.69	-1	23.85	22.75	141
12	38435.69	-0.5	23.7	22.75	141
13	38435.69	-0.5	23.65	22.7	140
14	38435.69	-0.5	23.55	22.65	141
15	38435.69	0	23.5	22.55	140
16	38435.69	0	23.45	22.5	140
17	38435.69	0	23.4	22.6	139
18	38435.69	0	23.35	22.65	138
19	38435.69	-0.5	23.35	22.55	142
20	38435.69	0	23.3	22.55	140

	A	B	C	D
1	datetimestamp	mptlat	mptlon	generic
2	4/14/2005	-1.94	-95.18	
3	4/15/2005	-2.13782	-95.122	
4	4/16/2005	-2.38613	-95.187	
5	4/17/2005	-2.63765	-95.268	
6	4/18/2005	-3.01094	-95.277	
7	4/19/2005	-3.34918	-95.239	
8	4/20/2005	-3.60097	-95.178	
9	4/21/2005	-3.64518	-95.282	
10	4/22/2005	-3.70406	-95.475	
11	4/23/2005	-3.62236	-95.244	
12	4/24/2005	-3.48975	-95.331	
13	4/25/2005	-3.36898	-95.08	
14	4/26/2005	-3.26997	-95.306	
15	4/27/2005	-3.36607	-95.393	
16	4/28/2005	-3.66048	-95.401	

Figure 4. Microwave Telemetry Archival Tag Data Files. [Top/Middle] Geophysical sensor time series at depth data (ambient temperature, pressure, light). Lower and higher frequency data sampling records in the Archival and Real-time blocks respectively. [Bottom] Light based geolocation positional estimates at time. Linkage between detailed geophysical values and positional data is via available matching date/time field values.

Archival Data					
Date/Time	Temp(val)	Temp(C)	Delta(val)	Δ Lim +Temp	Δ Lim -Temp
4/14/13 16:00	189	26.92	0		
4/14/13 16:15	206	30.09	0		
4/14/13 16:30	214	31.65	0		
4/14/13 16:45	191	27.28	0		
4/14/13 17:00	189	26.92	0		
4/14/13 17:15	189	26.92	-17		
4/14/13 17:30	189	26.92	-25		
4/14/13 17:45	189	26.92	-2		
4/14/13 18:00	189	26.92	X		
4/14/13 18:15	189	26.92	X		
4/14/13 18:30	188	26.73	X		
4/14/13 18:45	189	26.92	X		
4/14/13 19:00	188	26.73	-1		
4/14/13 19:15	188	26.73	-1		
4/14/13 19:30	188	26.73	0		

Real-Time Data		
Date/Time	Temp(val)	Temp(C)
4/28/13 15:22	179	25.13
4/28/13 19:32	181	25.48
4/28/13 23:54	179	25.13
4/29/13 02:32	179	25.13
4/29/13 02:40	179	25.13
4/29/13 04:07	179	25.13
4/29/13 06:34	179	25.13
4/29/13 08:01	179	25.13
4/29/13 09:45	179	25.13
4/29/13 10:25	179	25.13
4/29/13 10:33	179	25.13
4/29/13 14:54	179	25.13
4/29/13 15:17	179	25.13
4/29/13 19:19	183	25.84
4/29/13 19:35	183	25.84

	Archival Data						
2	Date/Time	Press(val)	Gain	Depth(m)	Delta(val)	Δ Lim Dives	Δ Lim Ascents
3	4/14/13 16:00	131	1	-6.1	0		
4	4/14/13 16:15	122	1	0.0	0		
5	4/14/13 16:30	122	1	0.0	0		
6	4/14/13 16:45	134	1	-8.1	0		
7	4/14/13 17:00	131	1	-6.1	0		
8	4/14/13 17:15	135	1	-8.7	13		
9	4/14/13 17:30	130	1	-5.4	8		
10	4/14/13 17:45	129	1	-4.7	-5		
11	4/14/13 18:00	129	1	-4.7	X		
12	4/14/13 18:15	127	1	-3.4	X		
13	4/14/13 18:30	128	1	-4.0	X		
14	4/14/13 18:45	127	1	-3.4	X		
15	4/14/13 19:00	136	1	-9.4	7		
16	4/14/13 19:15	126	1	-2.7	-1		
17	4/14/13 19:30	125	1	-2.0	-3		
18	4/14/13 19:45	128	1	-4.0	1		

Real-Time Data		
Date/Time	Press(val)	Depth(m)
4/28/13 15:22	61	0.0
4/28/13 19:32	61	0.0
4/28/13 23:54	61	0.0
4/29/13 02:32	61	0.0
4/29/13 02:40	61	0.0
4/29/13 04:07	61	0.0
4/29/13 06:34	61	0.0
4/29/13 08:01	61	0.0
4/29/13 09:45	61	0.0
4/29/13 10:25	61	0.0
4/29/13 10:33	61	0.0
4/29/13 14:54	61	0.0
4/29/13 15:17	61	0.0
4/29/13 19:19	61	0.0
4/29/13 19:35	61	0.0
4/29/13 23:34	61	0.0

1	pointid	dataname	year	month	day	mptlon	mptlat	varlon	vxy	vyx	varlat	taglon	taglat	tagsst	mptsst	kfsst
2	1	fit	2013	4	14	273.4	21.38	0	0	0	0	273.4	21.38		26.6453	
3	2	fit	2013	4	15	273.486	21.435	0.055602	0.010473	0.010473	0.097179	272.9351	9.537354	26.79775	26.6713	
4	3	fit	2013	4	16	273.739	21.5776	0.065383	0.021683	0.021683	0.153646	273.3701	20.59814	26.80042	26.7477	
5	4	fit	2013	4	17	274.135	21.7501	0.069197	0.027922	0.027922	0.182923	273.8067	21.97876	27.06307	26.8631	
6	5	fit	2013	4	18	274.495	22.0153	0.073384	0.029027	0.029027	0.192448	273.87	21.85181	27.21028	26.9328	
7	6	fit	2013	4	19	274.93	22.415	0.07659	0.026923	0.026923	0.186319	274.5601	23.9624	27.22683	26.959	
8	7	fit	2013	4	20	275.351	22.9126	0.080825	0.022871	0.022871	0.162781	275.2519	23.37524	27.12098	26.8764	
9	8	fit	2013	4	21	275.701	23.4816	0.085494	0.018517	0.018517	0.11929	275.6957	21.10596	26.90876	27.1186	
10	9	fit	2013	4	22	276.259	23.8208	0.089535	0.008558	0.008558	0.070987	277.6413	16.09131	26.8081	26.8921	
11	10	fit	2013	4	23	276.012	24.1417	0.090435	-0.00142	-0.00142	0.045068	276.089	24.17664	26.67905	26.6597	
12	11	fit	2013	4	24	275.722	24.5581	0.090847	-0.0044	-0.0044	0.039798	275.7887	25.16846	26.21709	26.3583	
13	12	fit	2013	4	25	275.374	24.7552	0.08983	-0.00783	-0.00783	0.036167	275.2405	24.65271	26.21133	26.2359	
14	13	fit	2013	4	26	275.105	24.9402	0.086052	-0.01016	-0.01016	0.036662	274.6945	26.96167	26.13914	26.1177	
15	14	fit	2013	4	27	275.099	25.111	0.070385	-0.00843	-0.00843	0.035633	275.1506	26.45386	25.98231	25.9783	

Summarized Popup Satellite Archival (PSAT) Data Formats

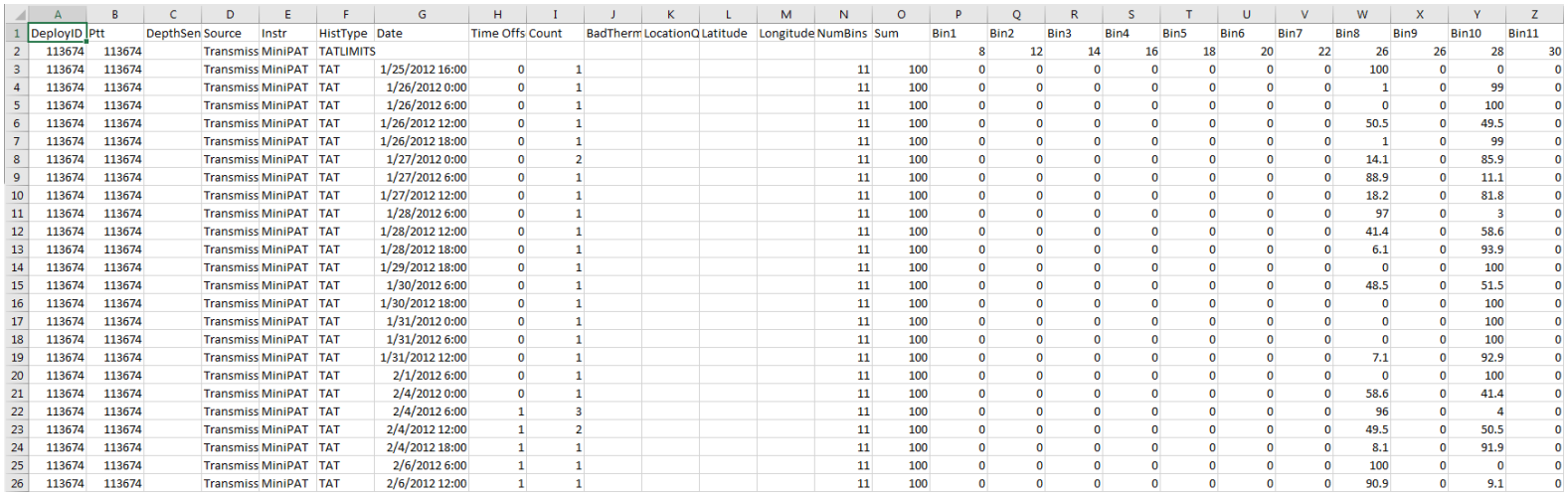
Typical extracts of summarized data outputs transmitted to satellite from PSAT tags that have successfully popped off the animal are illustrated in figures 5 and 6 below. Summary eTag data outputs take a variety of forms and are packaged in several CSV data product files by type. In the case, for example, of Wildlife computers CSV output data products include:
Argos.csv. Behavior.csv, Corrupt.csv, DivePDT.csv, DDN.csv, FastlocGPS.csv, HaulOut.csv, Histos.csv, Lightloc.csv, Locations.csv, X-Locations.csv, MixLayer.csv, PDTs.csv, Series.csv, SeriesRange.csv, SST.csv, Status.csv, STP.csv, Summary.csv, RTC.csv, Labels.csv, All.csv, GPE3.csv,DailyData.csv
Descriptions of these files and their contents is available from http://wildlifecomputers.com/wp-content/uploads/manuals/Spreadsheet-File-Descriptions.pdf. But of these, only a subset contain the core science data of interest; several of the other data files contain either ancillary information or alternate representations of the core data, with considerable overlap evident between products. The two products comprising the summarized science data of principal interest are:

- Time-At-Temperature and Time-At-Depth data: summarized bin-frequency temperature and depth distribution data for pre-programmed time intervals and bin classes (typically, 12-14 bin classes) from the source Histos.csv – figure 5
- Profile of Depth and Temperature (PDT): summarized Pressure/Depth/Temperature min/max range values for pre-programmed time intervals from the source *PDTs.csv* – figure 6

Locations:

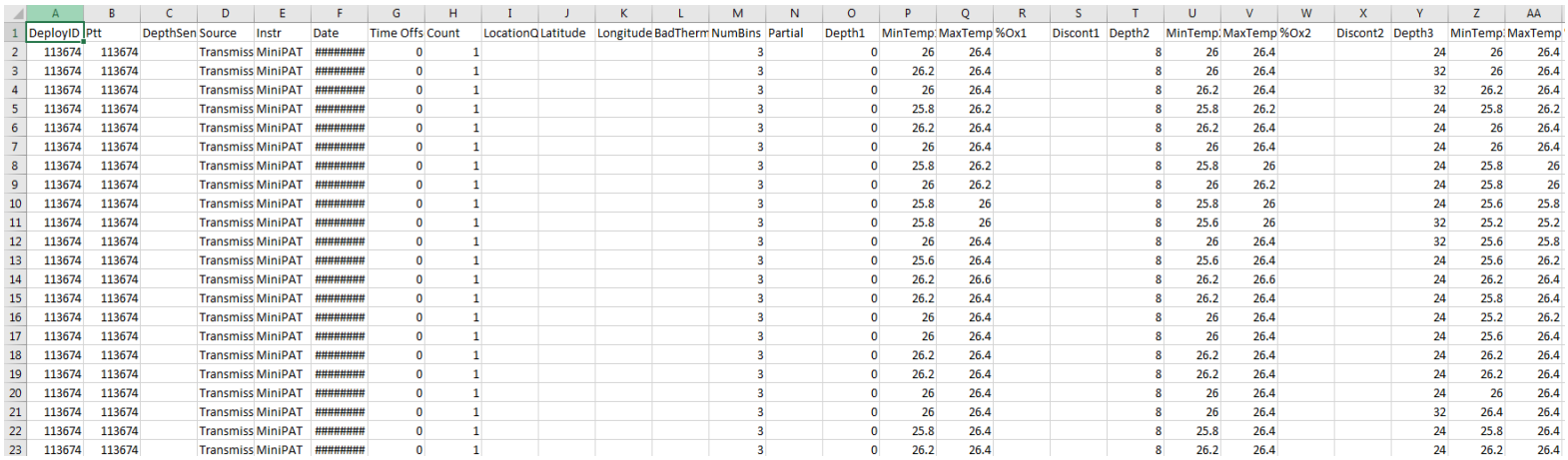
- Although not shown, daily light based geolocation positional estimates are available with both the aforementioned types of summarized output and resemble those in figure 3 for archival positional estimate outputs from the source *LightLoc.csv* and *Locations.csv* with geocorrected positions from the *GP3.csv* data file. Linkage of horizontal position and summarized vertical profile series is based on matching time stamp, although again there are likely to be differences in data frequency between point geolocation and time interval summary observations as in the case of full archival series.
- Other positional data provided include known Argos-based positions at the time of deployment and post pop-off are summarized in *Argos.csv*. Linkage between geophysical values in both detailed time series or summarized forms and positional data is via available matching date/time field values

Figure 5. Wildlife Computers PSAT Bin-Frequency Summary Data. Summarized bin-frequency temperature and depth distribution data for pre-programmed time intervals and bin classes (12-14). Daily light-based geolocation positional estimates are not shown here (equivalent to those in figure 2). Linkage between detailed geophysical values and positional data is via available matching date/time field values.



DeployID	Ptt	DepthSen	Source	Instr	HistType	Date	Time Offs	Count	BadTherm	LocationQ	Latitude	Longitude	NumBins	Sum	Bin1	Bin2	Bin3	Bin4	Bin5	Bin6	Bin7	Bin8	Bin9	Bin10	Bin11
113674	113674		Transmiss	MiniPAT	TATLIMITS										8	12	14	16	18	20	22	26	26	28	30
113674	113674		Transmiss	MiniPAT	TAT	1/25/2012 16:00	0	1					11	100	0	0	0	0	0	0	0	100	0	0	0
113674	113674		Transmiss	MiniPAT	TAT	1/26/2012 0:00	0	1					11	100	0	0	0	0	0	0	0	1	0	99	0
113674	113674		Transmiss	MiniPAT	TAT	1/26/2012 6:00	0	1					11	100	0	0	0	0	0	0	0	0	0	100	0
113674	113674		Transmiss	MiniPAT	TAT	1/26/2012 12:00	0	1					11	100	0	0	0	0	0	0	0	50.5	0	49.5	0
113674	113674		Transmiss	MiniPAT	TAT	1/26/2012 18:00	0	1					11	100	0	0	0	0	0	0	0	1	0	99	0
113674	113674		Transmiss	MiniPAT	TAT	1/27/2012 0:00	0	2					11	100	0	0	0	0	0	0	0	14.1	0	85.9	0
113674	113674		Transmiss	MiniPAT	TAT	1/27/2012 6:00	0	1					11	100	0	0	0	0	0	0	0	88.9	0	11.1	0
113674	113674		Transmiss	MiniPAT	TAT	1/27/2012 12:00	0	1					11	100	0	0	0	0	0	0	0	18.2	0	81.8	0
113674	113674		Transmiss	MiniPAT	TAT	1/28/2012 6:00	0	1					11	100	0	0	0	0	0	0	0	97	0	3	0
113674	113674		Transmiss	MiniPAT	TAT	1/28/2012 12:00	0	1					11	100	0	0	0	0	0	0	0	41.4	0	58.6	0
113674	113674		Transmiss	MiniPAT	TAT	1/28/2012 18:00	0	1					11	100	0	0	0	0	0	0	0	6.1	0	93.9	0
113674	113674		Transmiss	MiniPAT	TAT	1/29/2012 18:00	0	1					11	100	0	0	0	0	0	0	0	0	0	100	0
113674	113674		Transmiss	MiniPAT	TAT	1/30/2012 6:00	0	1					11	100	0	0	0	0	0	0	0	48.5	0	51.5	0
113674	113674		Transmiss	MiniPAT	TAT	1/30/2012 18:00	0	1					11	100	0	0	0	0	0	0	0	0	0	100	0
113674	113674		Transmiss	MiniPAT	TAT	1/31/2012 0:00	0	1					11	100	0	0	0	0	0	0	0	0	0	100	0
113674	113674		Transmiss	MiniPAT	TAT	1/31/2012 6:00	0	1					11	100	0	0	0	0	0	0	0	0	0	100	0
113674	113674		Transmiss	MiniPAT	TAT	1/31/2012 12:00	0	1					11	100	0	0	0	0	0	0	0	7.1	0	92.9	0
113674	113674		Transmiss	MiniPAT	TAT	2/1/2012 6:00	0	1					11	100	0	0	0	0	0	0	0	0	0	100	0
113674	113674		Transmiss	MiniPAT	TAT	2/4/2012 0:00	0	1					11	100	0	0	0	0	0	0	0	58.6	0	41.4	0
113674	113674		Transmiss	MiniPAT	TAT	2/4/2012 6:00	1	3					11	100	0	0	0	0	0	0	0	96	0	4	0
113674	113674		Transmiss	MiniPAT	TAT	2/4/2012 12:00	1	2					11	100	0	0	0	0	0	0	0	49.5	0	50.5	0
113674	113674		Transmiss	MiniPAT	TAT	2/4/2012 18:00	1	1					11	100	0	0	0	0	0	0	0	8.1	0	91.9	0
113674	113674		Transmiss	MiniPAT	TAT	2/6/2012 6:00	1	1					11	100	0	0	0	0	0	0	0	100	0	0	0
113674	113674		Transmiss	MiniPAT	TAT	2/6/2012 12:00	1	1					11	100	0	0	0	0	0	0	0	90.9	0	9.1	0

Figure 6. Wildlife Computers PSAT Summary PDT Data. Summarized Pressure/Depth/Temperature (PDT - Profile of Depth and Temperature) min/max range values for pre-programmed time intervals. Daily light based geolocation positional estimates are not shown here (equivalent to those in figure 2). Linkage between detailed geophysical values and positional data is via available matching date/time field values.



DeployID	Ptt	DepthSen	Source	Instr	Date	Time Offs	Count	LocationQ	Latitude	Longitude	BadTherm	NumBins	Partial	Depth1	MinTemp	MaxTemp	%Ox1	Discont1	Depth2	MinTemp	MaxTemp	%Ox2	Discont2	Depth3	MinTemp	MaxTemp
113674	113674		Transmiss	MiniPAT	########	0	1					3		0	26	26.4			8	26	26.4			24	26	26.4
113674	113674		Transmiss	MiniPAT	########	0	1					3		0	26.2	26.4			8	26	26.4			32	26	26.4
113674	113674		Transmiss	MiniPAT	########	0	1					3		0	26	26.4			8	26.2	26.4			32	26.2	26.4
113674	113674		Transmiss	MiniPAT	########	0	1					3		0	25.8	26.2			8	25.8	26.2			24	25.8	26.2
113674	113674		Transmiss	MiniPAT	########	0	1					3		0	26.2	26.4			8	26.2	26.4			24	26	26.4
113674	113674		Transmiss	MiniPAT	########	0	1					3		0	26	26.4			8	26	26.4			24	26	26.4
113674	113674		Transmiss	MiniPAT	########	0	1					3		0	25.8	26.2			8	25.8	26			24	25.8	26
113674	113674		Transmiss	MiniPAT	########	0	1					3		0	26	26.2			8	26	26.2			24	25.8	26
113674	113674		Transmiss	MiniPAT	########	0	1					3		0	25.8	26			8	25.8	26			24	25.6	25.8
113674	113674		Transmiss	MiniPAT	########	0	1					3		0	25.8	26			8	25.6	26			32	25.2	25.2
113674	113674		Transmiss	MiniPAT	########	0	1					3		0	26	26.4			8	26	26.4			32	25.6	25.8
113674	113674		Transmiss	MiniPAT	########	0	1					3		0	25.6	26.4			8	25.6	26.4			24	25.6	26.2
113674	113674		Transmiss	MiniPAT	########	0	1					3		0	26.2	26.6			8	26.2	26.6			24	26.2	26.4
113674	113674		Transmiss	MiniPAT	########	0	1					3		0	26.2	26.4			8	26.2	26.4			24	25.8	26.4
113674	113674		Transmiss	MiniPAT	########	0	1					3		0	26	26.4			8	26	26.4			24	25.2	26.2
113674	113674		Transmiss	MiniPAT	########	0	1					3		0	26	26.4			8	26	26.4			24	25.6	26.4
113674	113674		Transmiss	MiniPAT	########	0	1					3		0	26.2	26.4			8	26.2	26.4			24	26.2	26.4
113674	113674		Transmiss	MiniPAT	########	0	1					3		0	26.2	26.4			8	26.2	26.4			24	26.2	26.4
113674	113674		Transmiss	MiniPAT	########	0	1					3		0	26	26.4			8	26	26.4			24	26	26.4
113674	113674		Transmiss	MiniPAT	########	0	1					3		0	26	26.4			8	26	26.4			32	26.4	26.4
113674	113674		Transmiss	MiniPAT	########	0	1					3		0	25.8	26.4			8	25.8	26.4			24	25.8	26.4
113674	113674		Transmiss	MiniPAT	########	0	1					3		0	26.2	26.4			8	26.2	26.4			24	26.2	26.4