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IMOS NESP 5.9

Seagrass Aggregated Data Product

Product Technical Document

Version 1.0

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Australia's Integrated Marine Observing System (IMOS) is enabled by the National Collaborative Research Infrastructure Strategy (NCRIS). It is operated by a consortium of institutions as an unincorporated joint venture, with the University of Tasmania as Lead Agent.

IMOS acknowledges the Traditional Custodians and Elders of the land and sea on which we work and observe, and recognise them as Australia's first marine scientists and carers of sea Country. We pay our respects to Aboriginal and Torres Strait Islander peoples past and present.

1. Version History

Version	Date	Comments	Author
v1.0	December-2025	Initial Release	Galindo, T

Citation

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2. Background

2.1 Overview

Basis of the Seagrass Aggregated Data Product

The National Seagrass Data Aggregation consolidates many heterogeneous seagrass datasets into a single, standardised data product developed under Project 5.9. The purpose of the aggregation is to provide an analysis ready, nationally consistent seagrass dataset that supports ecological assessment, long term monitoring, and habitat modelling.

Source datasets were contributed by multiple Australian research institutions and government agencies, including IMAS, TropWATER (James Cook University), CSIRO, AIMS, and state and territory environment agencies. Data were accessed primarily via Seamap Australia GeoServer services, with supplementary static exports from institutional repositories.

The aggregation integrates data derived from a wide range of survey methods, including field-based GPS mapping, aerial and boat-based surveys, underwater video and sonar, UAV orthomosaics, and satellite-derived products. As a result, source datasets vary substantially in spatial resolution, temporal precision, taxonomic encoding, and data structure.

Spatial coverage spans Australian coastal waters nationwide, with dense coverage in regions including the Great Barrier Reef, Torres Strait, Gulf of Carpentaria, Moreton Bay, Hervey Bay, Cockburn Sound, and temperate southern coastlines. Temporal coverage extends from 1967 to 2024.

The product records presence and absence of 13 seagrass taxa. Species names are mapped to the Codes for Australian Aquatic Biota (CAAB) and aligned with World Register of Marine Species (WoRMS) taxonomy. Unresolved taxa (e.g. sp. or spp.) are standardised to the nearest resolved parent taxon, and biomass observations are retained where available.

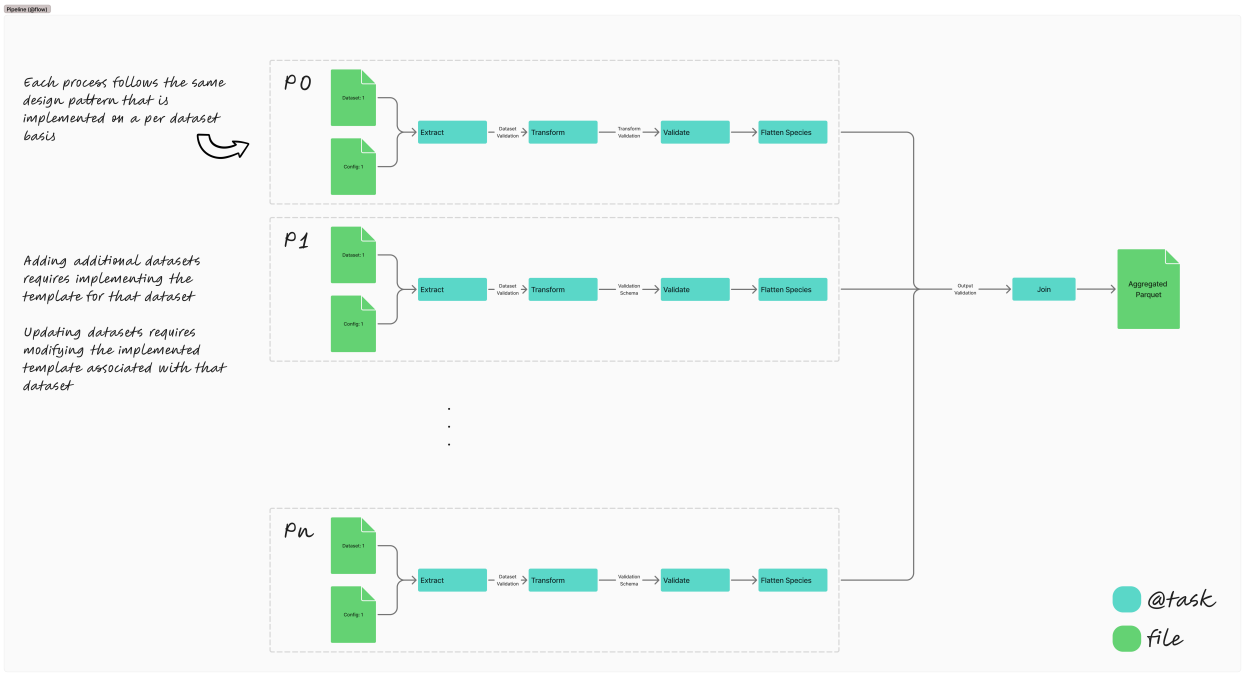
The final output is delivered as a long format Parquet dataset, with one record per species observation per site visit. Spatial enrichment includes H3 indices (resolution 15) and Australian Marine Region tags. Use of columnar storage and compression reduces the aggregated dataset from over 2 GB of source exports to approximately 230 MB.

3. Methodology

The Seagrass Aggregated Data Product (Data Product) relies on the standard Extract, Transform, and Load (ETL) methodology.

The ETL process to generate the Seagrass Aggregated Data Product is two step:

1. Transform source data to a harmonised intermediary standardised format
2. Transform intermediary harmonised data into singular data product



3.1 Extract

The Seagrass Aggregated Data Product is comprised of the following datasets:

Dataset	Metadata Title	metadata_link
GBR_NESP-TWQ-3.2.1-5.4_JCU_Seagrass_1984-2018_Site-surveys	Seagrass mapping synthesis: A resource for coastal management in the Great Barrier Reef (NESP TWQ 3.2.1 and NESP TWQ 5.4, TropWATER, James Cook University)	unknown
GoC_JCU_Marra-Sea-Country_2021_Seagrass_Deepwater-sites	Benthic habitats of Marra Sea Country - Gulf of Carpentaria - 2021 (JCU, Mabunji, CDU)	url
GoC_JCU_Marra-Sea-Country_2021_Seagrass_Site-Survey	Benthic habitats of Marra Sea Country - Gulf of Carpentaria - 2021 (JCU, Mabunji, CDU)	url
MaC_3_6_Furneaux	Mapping of subtidal temperate seagrass beds in Tayaritja (Furneaux group of islands), north-eastern Tasmania (NESP MaC 3.6)	unknown
NT_JCU_CDU_NESP-MaC-1-12_Yanyuwa-Seagrass-Sites_2021-2022	Benthic habitats of Yanyuwa Sea Country, Barni - Wardimantha Awara Indigenous Protected Area, Gulf of Carpentaria, Northern Territory, Australia (NESP MaC Project 1.12, JCU & CDU)	url
NT_JCU_Yanyuwa-Sea-Country_subtidal-sites_2022-2023	Subtidal benthic habitats of Yanyuwa Sea Country, Barni-Wardimantha Awara Indigenous Protected Area, Gulf of Carpentaria, Northern Territory, Australia	url
SeamapAus_NSW_estuarine_macrophytes_2022	NSW Estuarine Macrophytes 2023	url
SeamapAus_NT_Yanyuwa_seagrass_intertidal_2022	Benthic habitats of Yanyuwa Sea Country, Barni - Wardimantha Awara Indigenous Protected Area, Gulf of Carpentaria, Northern Territory, Australia (NESP MaC Project 1.12, JCU & CDU)	url

SeamapAus_NT_Yanyuwa_seagrass_subtidal_2023	Subtidal benthic habitats of Yanyuwa Sea Country, Barni-Wardimantha Awara Indigenous Protected Area, Gulf of Carpentaria, Northern Territory, Australia	url
SeamapAus_NT_seagrass_ArnhemKakaduGoC_2005	Seagrass meadows of Arnhem Land, Kakadu and Gulf of Carpentaria	url
SeamapAus_QLD_GreenIsland_seagrass_2020	Seagrass meadow extents derived from field to spaceborne earth observation at Green Island (Wunyami), a reef habitat in the Cairns section of the Great Barrier Reef, November 2020	url
SeamapAus_QLD_HerveyBay_seagrass_1998	Seagrass meadows of Hervey Bay and the Great Sandy Strait, Queensland, derived from field surveys conducted 6-14 December, 1998	url
SeamapAus_QLD_LizardIsland_2014	Habitat Map for Lizard Island reef, Australia derived from a photo-transect survey field data collected in December 2011 and September/October 2012	url
SeamapAus_QLD_LowIsles_seagrass_1997	Seagrass and associated benthic community data derived from field surveys at Low Isles, Great Barrier Reef 1997	url
SeamapAus_QLD_MidgePoint_seagrass_2017	Seagrass meadows extents derived from field to spaceborne earth observation at Midge Point, Great Barrier Reef, September/October 2017	url
SeamapAus_QLD_MoretonBay_seagrass_2004	Habitat map of seagrass cover derived from a supervised moderate-spatial-resolution multi-spectral satellite image, integrated with manual delineation and coincident field data, Moreton Bay, 2004	url
SeamapAus_QLD_MoretonBay_seagrass_2011	Habitat map of seagrass cover derived from a supervised moderate-spatial-resolution multi-spectral satellite image,	url

	integrated with manual delineation and coincident field data, Moreton Bay, 2011	
SeamapAus_QLD_MoretonBay_seagrass_2015	Seagrass cover map for the optically complex waters of Moreton Bay, Queensland	url
SeamapAus_QLD_TorresStrait_seagrass_consolidation_intertidal_2014	Torres Strait seagrass mapping consolidation 2002-2014	url
SeamapAus_QLD_TorresStrait_seagrass_consolidation_subtidal_2014	Torres Strait seagrass mapping consolidation 2002-2014	url
SeamapAus_QLD_YulePoint_seagrass_2019	Seagrass meadow extents derived from field to spaceborne earth observation at Yule Point, Great Barrier Reef, October 2017 to July 2020	url
SeamapAus_SA_state_benthic_habitats_2013	South Australia State Marine Benthic Habitats (DEWNR)	url
SeamapAus_SA_state_estuarine_habitats_2009	Estuarine Habitats of South Australia	url
SeamapAus_VIC_statewide_habitats_2023	Victorian Statewide Marine Habitat Map 2023	url
SeamapAus_WA_CockburnSound_seabed_2004	Mapping of selected areas of Cockburn Sound, Western Australia	url
SeamapAus_WA_CockburnSound_seagrass_1967	Changes in seagrass coverage in Cockburn Sound, Western Australia between 1967 and 1999	url
SeamapAus_WA_CockburnSound_seagrass_1972	Changes in seagrass coverage in Cockburn Sound, Western Australia between 1967 and 1999	url
SeamapAus_WA_CockburnSound_seagrass_1981	Changes in seagrass coverage in Cockburn Sound, Western Australia between 1967 and 1999	url
SeamapAus_WA_CockburnSound_seagrass_1995	Changes in seagrass coverage in Cockburn Sound, Western Australia between 1967 and 1999	url
SeamapAus_WA_CockburnSound_seagrass_1999	Changes in seagrass coverage in Cockburn Sound, Western Australia between 1967 and 1999	url

SeamapAus_WA_EOMAP_AshmoreCartier_2022	Satellite Mapping of Bathymetry and Habitats of Ashmore Reef and Cartier Island Marine Parks	url
SeamapAus_WA_IMSA_seafloor_Lancelin_2017	Very High Resolution Seafloor Classification and Satellite Derived Bathymetry of Lancelin, Australia (IMSA)	url
SeamapAus_WA_IMSA_seafloor_Swanbourne_2019	Very High Resolution Seafloor Classification and Satellite Derived Bathymetry of Swanbourne, Australia (IMSA)	url
SeamapAus_WA_JurienBay_benthic_habitat_2018	Jurien Bay benthic habitat mapping	url
SeamapAus_WA_Seagrass_Synthesis_2023_Hardy	Hardy Inlet Seagrass Survey - Cover (DWER-112)	url
SeamapAus_WA_Seagrass_Synthesis_2023_Leschenault	Leschenault Estuary Seagrass Survey - Cover (DWER-105)	url
SeamapAus_WA_Seagrass_Synthesis_2023_OysterHarbour	Oyster Harbour Seagrass Survey - Cover (DWER-109)	url
SeamapAus_WA_Seagrass_Synthesis_2023_PeelHarvey	Bindjareb Djilba (Peel Harvey) Seagrass Survey - Cover (DWER-128)	url
SeamapAus_WA_Seagrass_Synthesis_2023_PrincessRoyal	Princess Royal Harbour Seagrass Survey - Cover (DWER-131)	url
SeamapAus_WA_Seagrass_Synthesis_2023_Wilson	Wilson Inlet Seagrass Survey - Cover (DWER-114)	url
TS-GOC_JCU_NESP-MaC-1-13_Seagrass-sites_1983-2022	Four Decades of Seagrass Spatial Data from Torres Strait and Gulf of Carpentaria (NESP MaC Project 1.13, TropWATER JCU)	url
TS_JCU_Dungeness-Reef_2016_Seagrass_Intertidal-Site-Surveys	Dungeness Reef Seagrass Survey, Torres Strait,2016	unknown
TS_JCU_Dungeness-Reef_2017_Seagrass_Community-type	Dungeness Reef Seagrass Survey, Torres Strait, 2017 (Community Type)	unknown
TS_JCU_Dungeness-Reef_2017_Seagrass_Subtidal-Site-Surveys	Dungeness Reef Seagrass Survey, Torres Strait, 2017 (Site-Surveys)	unknown
TS_JCU_Dungeness-Reef_2019_Seagrass_Community-type	Dungeness Reef Seagrass Survey, Torres Strait, February 2019	url

	(TropWATER, James Cook University)	
TS_JCU_Dungeness-Reef_2019_Seagrass_Site-Survey	Dungeness Reef Seagrass Survey, Torres Strait, February 2019 (TropWATER, James Cook University)	url
TS_JCU_Dungeness-Reef_2020_Seagrass_Community-type	Dungeness Reef Seagrass Survey, Torres Strait, February 2019 (TropWATER, James Cook University)	url
TS_JCU_Dungeness-Reef_2020_Seagrass_Site-Survey	Dungeness Reef Seagrass Survey, Torres Strait, February 2019 (TropWATER, James Cook University)	url
TS_JCU_Dungeness-Reef_2021_Seagrass_Community-type	Dungeness Reef Seagrass Survey, Torres Strait, February 2021 (TropWATER, James Cook University)	url
TS_JCU_Dungeness-Reef_2021_Seagrass_Site-Survey	Dungeness Reef Seagrass Survey, Torres Strait, February 2021 (TropWATER, James Cook University)	url
TS_JCU_Eastern-Torres-Strait_2020_Seagrass-community-type	Eastern Torres Strait Seagrass Survey, Torres Strait, 2020	unknown
TS_JCU_Orman-Reefs_2017_Seagrass_Community-type	Seagrass baseline survey for Orman Reef, Torres Strait, 2017 (TropWATER, JCU)	url
TS_JCU_Orman-Reefs_2017_Seagrass_Site-surveys	Seagrass baseline survey for Orman Reef, Torres Strait, 2017 (TropWATER, JCU)	url
TS_JCU_Orman-Reefs_2018_Seagrass_Community-type	Orman Reef Seagrass Survey, Torres Strait, November 2018 (TropWATER, JCU)	url
TS_JCU_Orman-Reefs_2018_Seagrass_Site-Surveys	Orman Reef Seagrass Survey, Torres Strait, November 2018 (TropWATER, JCU)	url
TS_JCU_Orman-Reefs_2019_Seagrass_Community-type	Orman Reef Seagrass Survey, Torres Strait, September 2019 (TropWATER, James Cook University)	url
TS_JCU_Orman-Reefs_2019_Seagrass_Site_Survey	Orman Reef Seagrass Survey, Torres Strait, September 2019	url

s	(TropWATER, James Cook University)	
TS_JCU_Western-Torres-Strait_2020_Seagrass-community-type	Western Torres Strait Seagrass Survey, Torres Strait, September 2020 (TropWATER, JCU)	url
TS_JCU_Western-Torres-Strait_2020_Seagrass_Site-surveys	Western Torres Strait Seagrass Survey, Torres Strait, September 2020 (TropWATER, JCU)	url

Data Source

The underlying data is typically sourced from geo-servers maintained by:

1. IMAS
2. JCU
3. NESP

Extraction of the original datasets was conducted prior construction of the ETL pipeline.

There are plans to replace the static exports with dynamic exports from source.

Validation

Each dataset was analysed to understand its scheme and is validated against its own custom schema custom schema.

While there are similarities between each dataset, the column names, biological information and geometries have subtle differences that had to be accounted for per dataset.

Minimum Required Fields

The minimum required fields are the standard biological datasets: when, where and what.

Column	Typical Type	Description	Typical Data Quality
Geometry	string	Usually a WKT encoding of the biological occurrence	Good
Date	string	Usually an ISO8601 or similar encoded string	Poor
Species	string or comma separated string	Either a list of scientific names or one hot encoded scientific names	Good

This is a minimum example of a categorical encoded seagrass dataset schema:

```
"pyarrow_schema": {
    "fields": [

        // When
        {
            "name": "Date",
            "type": "date32[day]",
            "nullable": false,
            "date_encoding": "start_date"
        },

        // Where: The wkt geometry encoded in epsg:4326
        {
            "name": "geom",
            "type": "string",
            "nullable": false,
            "projection": 4326,
            "format": "wkt"
        },

        // What: Species present at the geometry
        {
            "name": "SM_HAB_CLS",
            "type": "string",
            "nullable": false,
            "aggregate_encoding": "presence"
        },
    ],
}
```

At runtime, the input data is validated per dataset against its custom schema, ensuring correct type interpretation for CSV data.

Extraction

Extraction is handled via the `common.file.S3Block` class in conjunction with the `common.factory.PyarrowTableFactory` class.

These serializable pydantic classes allow the extraction to live as JSON configuration files, saved in this project as `<dataset>.factory.json` files and ensure type valided arrow is generated from CSV inputs:

```
{
    "file_interface": {
        "block_name": "processing-bucket",
        "path": "seagrass/TS_JCU_Western-Torres-Strait_2020_Seagrass-community-
type.csv"
    },
    "format": "csv",
    "pyarrow_schema": {
        "fields": [

            // When
            {
                "name": "Date",
                "type": "date32[day]",
                "nullable": false,
                "date_encoding": "start_date"
            },

            // Where: The wkt geometry encoded in epsg:4326
            {
                "name": "geom",
                "type": "string",
                "nullable": false,
                "projection": 4326,
                "format": "wkt"
            },

            // What: Species present at the geometry
            {
                "name": "SM_HAB_CLS",
                "type": "string",
                "nullable": false,
                "aggregate_encoding": "presence"
            },
        ],
    }
}
```

3.2 Transform

Because the underlying seagrass data sources have unique time, place and species encodings, the Seagrass Aggregate Data Product transformations are bespoke to each source.

Per Dataset Transformation Pattern

The typical transformation pattern procedure is as follows:

1. Extract geometry
2. Extract date
3. Extract species presence/absence

Extract Geometry

Because the export data uses a WKT export query paramter, the geometry column almost always contains WKT compliant geometry information. This allows the latitude and longitude to be located.

Where the geometry column is unavailable, the latitude and longitude are used as a substitue.

Extract Date

Date information is usually ISO8601 compliant, but in many cases is not.

The dates are manually audited and mapped where the date encoding is non ISO8601 compliant and follows inconsistent patterns, eg:

```
start_year = dates.map(
    {
        "16/12/2020": 2020,
        "Dec-19": 2019,
        "2015-2016": 2015,
        "10,17,19,27/5/22": 2022,
        "December-2010, November-2011": 2010,
        "Jun-21": 2021,
        "May/June-2012": 2012,
        "2-4/11/2020": 2020,
        "May-2020": 2020,
        "14-18/11/22": 2022,
        "October, 2017": 2017,
        "Aug-20": 2020,
        "9/02/2022,16/02/2022": 2022,
        "October-2010": 2010,
        "2005,2008": 2005,
        "27-28/10/2021": 2021,
        "21/07/2022": 2022,
        "22-24/09/2020": 2020,
        "Nov-19": 2019,
        ...
    }
)

start_month = dates.map(
    {
        "16/12/2020": 12,
        "Dec-19": 12,
        "2015-2016": 0,
        "10,17,19,27/5/22": 5,
        "December-2010, November-2011": 12,
        "Jun-21": 6,
        "May/June-2012": 5,
        "2-4/11/2020": 11,
        "May-2020": 5,
        "14-18/11/22": 11,
        "October, 2017": 10,
        "Aug-20": 8,
        "9/02/2022,16/02/2022": 2,
        "October-2010": 10,
        "2005,2008": 1,
        "27-28/10/2021": 10,
        "21/07/2022": 7,
        "22-24/09/2020": 9,
        "Nov-19": 11,
        ...
    }
)

start_day = dates.map(
    {
        "16/12/2020": 16,
        "Dec-19": 0,
        "2015-2016": 0,
        "10,17,19,27/5/22": 10,
```

```
        "December-2010, November-2011": 0,
        "Jun-21": 0,
        "May/June-2012": 0,
        "2-4/11/2020": 2,
        "May-2020": 0,
        "14-18/11/22": 14,
        "October, 2017": 0,
        "Aug-20": 0,
        "9/02/2022,16/02/2022": 9,
        "October-2010": 0,
        "2005,2008": 0,
        "27-28/10/2021": 27,
        "21/07/2022": 21,
        "22-24/09/2020": 22,
        "Nov-19": 0,
    }
)
```

Extract Species Presence/Absence

The typical species data transforms are to:

1. Re-encode delimited string columns
2. Re-encode one hot encoded species
3. Map species to the Codes for Australian Aquatic Biota controlled vocabulary (CAAB)
4. Disambiguation of species

Delimited String Species

The presence/absence of species are commonly encoded in a delimited string column.

In these cases, the column values were audited and mapped to the CAAB controlled vocabulary.

eg:

Species
"HO, HA, AO"
"HO, HA"
"AO"

One Hot Encoded Species

The presence/absence of species are also commonly one hot encoded.

In these cases, the column names were audited and mapped to the CAAB controlled vocabulary.

eg:

HO	HA	AO
TRUE	TRUE	TRUE
TRUE	TRUE	FALSE
FALSE	FALSE	TRUE

Species Mapping

The species were mapped to the CAAB controlled vocabulary. Details of this vocabulary are found in the enumeration.py.

Species Disambiguation

Another issue commonly encountered is the usage of `sp.` or `spp.`. In such instances, the scientific name is rolled up to the nearest parent.

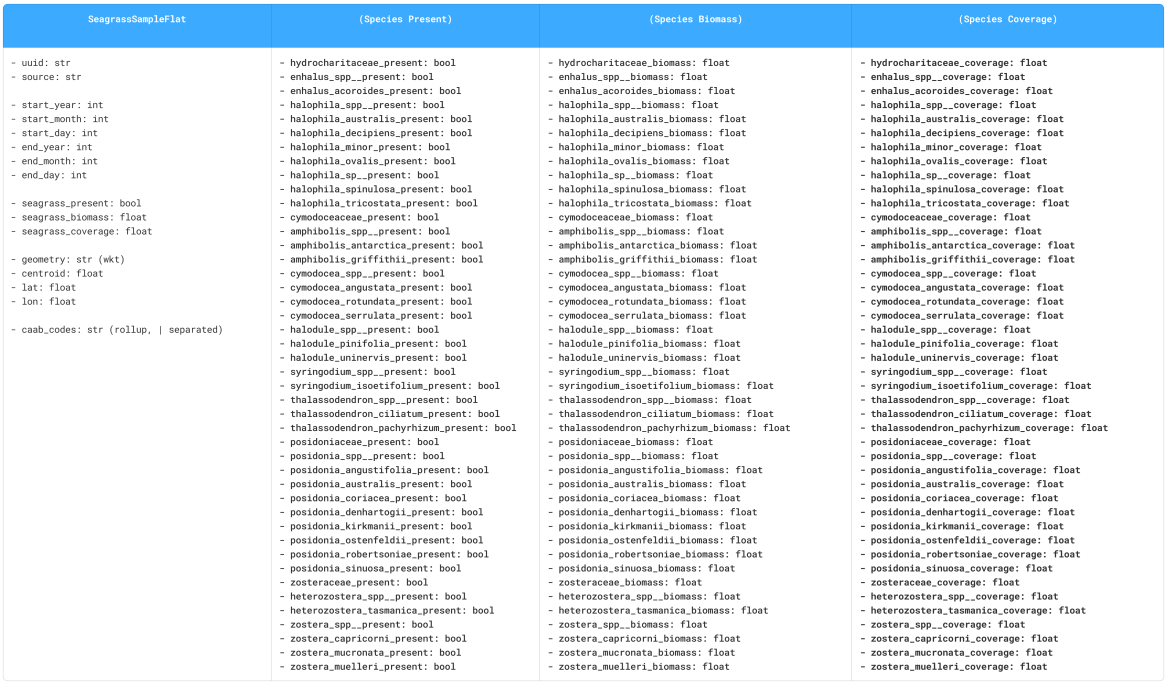
Per Dataset Transformation Validation

Once a dataset it is validated against an intermediary schema:

name	type	nullable
source	string	false
source_id	string	false
metadata_link	string	false
*When *	-	-
start_year	int16	false
start_month	int8	true
start_day	int8	true
end_year	int16	true
end_month	int8	true
end_day	int8	true
*Where *	-	-
geometry	string	false
What	-	-
seagrass_present	bool	false

thalassia_present	bool	true
thalassia_hemprichii_present	bool	true
hydrocharitaceae_present	bool	true
enhalus_present	bool	true
enhalus_acoroides_present	bool	true
halophila_present	bool	true
Species continues...	-	-

The full output schema is shown below:



Post Processing

Once extract transform is complete per dataset, the harmonised data is stacked vertically ready for post processing.

Wide to Long Pivot

The intermediary transformed data is kept in wide format to simplify translation of species.

The final dataset however is pivoted to long format to improve usability.

Output Validation

The long format output table is validated against the schema below:

name	type	nullable	is_list	metadata.description	metadata.unit
source	string	false	false	The source dataset name	null
source_id	string	false	false	The source dataset row id	null
metadata_link	string	false	false	The source dataset metadata link	null
start_year	int16	false	false	The start year of the measurement	null
start_month	int8	true	false	The start month of the measurement	null
start_day	int8	true	false	The start day of the measurement	null
end_year	int16	true	false	The end year of the measurement (if applicable)	null
end_month	int8	true	false	The end month of the measurement (if applicable)	null
end_day	int8	true	false	The end day of the measurement (if applicable)	null
geometry	string	false	false	The WKT encoded geometry of the measurement	null
lat	float32	false	false	The latitude of the measurement, taken from the centroid of the geometry	null

lon	float32	false	false	The longitude of the measurement, taken from the centroid of the geometry	null
h3_index	string	false	false	A hexadecimal string representing a H3 polygon at resolution 5, derived from the latitude and longitude	null
australian_marine_regions_tags	string	true	false	The australian marine regions tags found applicable to the measurement	null
present	boolean	false	false	The presence of the species of the measurement	null
biomass	float32	true	false	The biomass of the species of the measurement (if applicable, most studies only measure presence)	gdw/m^2
scientific_name	string	false	false	The scientific name of the measurement, as per WoRMS catalogue	null
aphia_id	int64	false	false	The scientific name aphia id of the measurement, as per WoRMS catalogue	null
rank	string	false	false	The taxon rank of the	null

				measurement, as per WoRMS catalogue	
status	string	false	false	The taxon acceptance of the measurement, as per WoRMS catalogue	null

3.3 Load

Finally, the transformed Parquet is loaded to the s3://data-uplift-public/stored/datauplift/ bucket as a Parquet file..

4. Flow Advantages

Reproducibility The original Squidle+ relational schema requires deep database expertise to join and flatten. This ETL procedure provides a reliable, replicable path to a flat Darwin Core standard.

Harmonisation the original seagrass data have unique schemes and data encodings which require per dataset effort to harmonise. The pre-harmonisation of this data into an anlysis read product allows scientists to focus on the analysis instead of data wrangling.

Space Efficiency static geo server exports are reduced from 2gb+ to **~230MB** with modern compression and file formats (Parquet), optimising storage and access

Time Efficiency scheduled updates allow users to access up-to-date aggregated data without re-implementing the aggregation steps and validation

Cloud-native workflows reduce I/O overhead