CATAMI classification scheme for scoring marine biota and substrata in underwater imagery

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1. Introduction

Transforming raw underwater imagery into quantitative information useful for science and policy decisions requires substantial manual effort by human experts. This process will soon become unsustainable as the volume of imagery being collected continues to increase due to technological advances in the acquisition and resolution of imagery. Currently there is a lack of standardised approaches to the methodology, annotation, classification and analysis of this imagery. This makes comparison across disparate sites as well as further analysis very difficult. The CATAMI (Collaborative and Annotation Tools for Analysis of Marine Imagery and video) project aims to help solve some of these issues by working with the NERP Marine Biodiversity Hub - Theme 1 and the marine community to develop a standard classification scheme for scoring marine biota and physical characteristics from underwater imagery.

There is a growing consensus between organisations that collect underwater imagery that greater collaboration is key to ensuring optimal utility from this data. A standardised classification scheme will assist the whole marine community by enabling aggregation, annotation and automated processing of imagery thereby saving resources and maximising the use of the limited number of taxonomic staff.

This document will outline the background to this classification and how it will be implemented to ensure researchers make best use of the great variety of imagery from Baited Remote Underwater Video (BRUV), Autonomous Underwater Vehicles (AUV), Towed Video / Imagery (TV/TI), Diver Operated Video (DOV) and Photo Quadrats.

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2. Background

2.1 Ideal characteristics of a marine habitat classification scheme

In a review of habitat classifications, Ball et al. (2006) identified the following characteristics of successful classification schemes:

- *The scheme should be hierarchical (to avoid duplication of categories)*
- *Classes should be mutually exclusive and exhaustive at each level in the hierarchy (so that each habitat type is accounted for and unique)*
- *The scheme should be comprehensive (at least at the upper levels of the scheme)*
- *The scheme should provide a common and easily-understood language for descriptions*
- *All sensing techniques should result in the same classifications, though the level to which a habitat can be classified will be dependent on the resolution of the sensor*
- *Habitat variables that change slowly (e.g. substrate) should be placed higher in the scheme than those that change rapidly (e.g. biota)*
- *Classes should be sufficiently fine to be of practical use for local managers,*

but also be sufficiently broad (through the hierarchy) as to allow summary information to be presented at national or international scales or to nonspecialists
• The scheme should be flexible enough that it can be modified when new information is presented, but also be stable enough that it can support ongoing use. Changes should be clearly documented and related back to earlier categories.

The classification outlined in this document matches these characteristics. Details on previous work and the basis for developing this classification are outlined below.

2.2 Previous work

It is acknowledged that there has been a great deal of work by many different organisations and individuals in developing classification schemes. Where possible we have sought to reuse and learn from these efforts while following characteristics outlined in Ball et. al. (2006). Mount et. al. (2007) provides an overview of national and state-based approaches and our classification shares many similarities such as the hierarchical structure. The hierarchical structure permits researchers the flexibility to go into as much detail as desired for project-specific purposes but allows for 'higher' level comparison of data across Australia.

Relevant (but not exhaustive) past studies / reviews:

Ball, D., Blake, S. and Plummer, A. (2006). Review of Marine Habitat Classification Systems. Parks Victoria Technical Series No. 26. Parks Victoria, Melbourne. (http://parkweb.vic.gov.au/__data/assets/pdf_file/0003/314463/19_1855.pdf)

David W. Conner, James H. Allen, Neil Golding, Kerry L. Howell, Louise M. Lieberknecht Kate O. Northen and Johnny B. Reker. (2004). The Marine Habitat Classification for Britain and Ireland Version 04.05 JNCC, Peterborough. ISBN 1 861 07561 8 (internet version) jncc.defra.gov.uk/MarineHabitatClassification

Diaz, R. J., M. Solan and R. Valente (2004). "A review of approaches for classifying benthic habitats and evaluating habitat quality." Journal of Environmental Management (73): 165-181. (http://dx.doi.org/10.1016/j.jenvman.2004.06.004)

Greene, H.Gary , Mary M Yoklavich, Richard M Starr, Victoria M O'Connell, W.Waldo Wakefield, Deidre E Sullivan, James E McRea Jr., Gregor M Cailliet, A classification scheme for deep seafloor habitats, Oceanologica Acta, Volume 22, Issue 6, November–December 1999, Pages 663-678, ISSN 0399-1784, (http://dx.doi.org/10.1016/S0399-1784(00)88957-4)

Joint Nature Conservation Committee (JNCC). Edited by Jon Davies (senior editor), John Baxter, Martin Bradley, David Connor, Janet Khan, Eleanor Murray, William Sanderson, Caroline Turnbull and Malcolm Vincent. UK Marine Monitoring Handbook (2001) http://jncc.defra.gov.uk/PDF/MMH-mmh_0601.pdf

Mount, R., Bricher, P. and Newton, J. (2007). National Intertidal/Subtidal Benthic

(NISB) Habitat Classification Scheme. Australian Greenhouse Office; National Land & Water Resources Audit; School of Geography and Environmental Studies, University of Tasmania (http://lwa.gov.au/files/products/national-land-and-water-resources-audit/pn21267/pn21267.pdf)

2.3 Why not use an existing classification?

There are a variety of reasons why CATAMI has decided to create a more relevant classification. The reasons for not using an existing classification include:

a) Too detailed
b) Not detailed enough
c) Not appropriate for video / imagery 'within image' scoring and analysis
d) Lacking taxonomy / morphology characteristics suited to imagery

An example is the Marine Habitat Classification for Britain & Ireland (v04.05) - which is part of the 'European Nature Information System' (EUNIS) habitat classification. Even though this is hierarchical in nature it wouldn't be feasible to implement as they are defining 'habitats'; most likely from an entire frame or section of imagery / video. We wish to capture and identify biota at points within an image and at a whole image level.

The conceptual basis for this classification was to create a taxonomy-based system that includes morphological categories to take into account the fact that it is not always possible to identify biota to species or genus level from imagery. For example, some taxa such as sponges can only be classified to a broad morphology rather than a taxonomic group from imagery alone. The classification also needed to be simple and easy to implement across all collection methods and tools, geographic extents (e.g. tropical, temperate, shallow, deep) and sampling resolutions.

Finally we wanted to ensure it was sustainable. The classification is mostly taxonomy based so it could be easily incorporated into the existing Codes for Australian Aquatic Biota (CAAB). This has advantages which will be outlined in section 4.

2.4 Previous versions - changes

Versions 1.0 - 1.1 contained various iterations that were updated through 2012 and early 2013. At the AMSA 2012 conference it was discussed and in October 2012 a draft was circulated. Version 1.0 was released in late February 2013 and Version 1.1 was released in April 2013.

Version 1.2 was released in August 2013, this was the first version to be documented in a pictorial guide. The classification was a product of several workshops and extensive discussions among scientists interested in scoring marine underwater imagery. The classification was also presented and discussed at AMSA 2013. There were changes to coral, physical categories, seagrasses, worms from Version 1.1.

Version 1.3 released in December 2013. This version contains two changes from V1.2:

(1) An update in the hierarchical structure of the Sponges- CAAB 10 000000 which reflects the updated 'Cheat Sheet' of functional sponge morphologies finalised by Schönberg & Fromont 2013 after the 9th World Sponge Conference 2013, Fremantle (http://www.spongeconference2013.org/home). For details see Table below.
(2) Addition of a sub-division (i.e. additional branches in the tree) in the Macroalgae: Encrusting: Red – CAAB 80 300929 category – two sub-categories. For details see Table below.

Version 1.4 released in December 2014. This version contains the following changes from V1.3:

(1) Update of NERP Marine Biodiversity Hub logo on front page
(2) Correction of classification for example image pg 70 'Unstalked solitary ascidian with elongate siphons' was removed as incorrect identification – image moved to pg 59 Ctenophora (benthic) Lyrocteis sp. —with thanks to D. Lindsey (JAMSTEC) for the correction.
(3) Updated publication reference for Gershwin et al. in prep, now Gershwin et al. 2014
(4) Update of sponge classifications and publication reference now Schönberg & Fromont 2014; incorporated sponge classification example images into the CATAMI visual guide.
(5) The Visual guide V1.4 (Althaus et al 2013) includes these changes and in addition new/updated references and one correction of a misidentified image

Version 1.1 → 1.2

CATAMI CAAB CODE	CATAMI DISPLAY NAME	CATAMI CAAB PARENT CODE	CHANGE
20 000908	Bryozoa: Hard: Branching	20 000901	New category
11 171000	Cnidaria: Corals: Black & Octocorals: Blue coral (Heliopora)	11 168901	New category
11 168920	Cnidaria: Corals: Black & Octocorals: Massive soft corals	11 168901	New category
11 201901	Cnidaria: Corals: Black & Octocorals: Organ pipe coral (Tubipora)	11 168901	New category
11 290907	Cnidaria: Corals: Stony corals: Foliose / plate	11 290000	11290914 - Cnidaria: Corals: Stony corals: Lattice-forming - deleted (include in 11290912)
11 290901	Cnidaria: Corals: Stony corals: Solitary	11 290000	Changed name (was: Cnidaria: Corals: Stony corals: Solitary / Mushroom)
11 290903	Cnidaria: Corals: Stony corals: Solitary: Attached	11 290901	Changed name (was: Cnidaria: Corals: Stony corals: Solitary / Mushroom: Attached)

11 290902	Cnidaria: Corals: Stony corals: Solitary: Free-living	11 290901	Changed name (was: Cnidaria: Corals: Stony corals: Solitary / Mushroom: Free-living)
11 298000	Cnidaria: Corals: Stony corals: Solitary: Mushroom (Fungiidae)	11 290901	New category
11 077906	Cnidaria: Hydrocorals: Branching	11 077000	New category
11 077907	Cnidaria: Hydrocorals: Submassive / encrusting	11 077000	New category
28 836000	Crustacea: Crabs: King crabs	28 000903	New category
28 825903	Crustacea: Hermit crabs: With anemones	28 825901	Name change
28 825902	Crustacea: Hermit crabs: With shell or stone home	28 825901	Name change
23 607000	Molluscs: Cephalopods: Cuttlefish	23 590000	New category
82 003007	Relief: High: Wall	82 003005	Changed name (was: Relief: High: Rock wall)
63 600902	Seagrasses: Elliptical leaves	80 000901	New category
63 600903	Seagrasses: Strap-like leaves	80 000901	New category
82 001018	Substrate: Unconsolidated (soft): Pebble / gravel: Biologenic: Rhodoliths	82 001007	New category
82 001017	Substrate: Unconsolidated (soft): Pebble / gravel: Biologenic: Screwshells	82 001007	New category
80 600901	Worms	80 000000	80600902 (Worms: Echiura / Sipuncula) deleted - go straight to 17020000 and 17000000
17 020000	Worms: Echiura	80 600901	Name, parent ID changed (was Worms: Echiura / Sipuncula: Echiura)
17 000000	Worms: Sipuncula	80 600901	Name, parent ID changed (was Worms: Echiura / Sipuncula: Sipuncula)

Version 1.2 → 1.3

CATAMI CAAB CODE	CATAMI DISPLAY NAME	CATAMI CAAB PARENT CODE	CHANGE
10 000917	Sponges: Crusts: Creeping / ramose	10 000901	New category
10 000906	Sponges: Erect forms: Stalked	10 000912	Changed name (10000906 - Sponges: Massive forms: Stalked - Deleted and placed here)
10 000919	Sponges: Hollow forms: Cups and alikes: Cup / goblet	10 000910	New category

10 000918	Sponges: Hollow forms: Cups and alikes: Incomplete cup / curled fan	10 000910	New category
10 000920	Sponges: Hollow forms: Tabular	10 000909	New category
10 000905	Sponges: Massive forms: Balls	10 000903	Changed name (was Sponges: Massive forms: Radially organised)
80 300934	Macroalgae: Encrusting: Red: Calcareous	80 300929	New category
80 300935	Macroalgae: Encrusting: Red: Non-calcareous	80 300929	New category

Version 1.3 → 1.4

CATAMI CAAB CODE	CATAMI DISPLAY NAME	CATAMI CAAB PARENT CODE	CHANGE
10 000901	Sponges: Crusts: Endolithic / bioeroding	10 000921	New category
10 000909	Sponges: Cup-likes	10 000000	Changed name: was 'Hollow forms'
10 000910	Sponges: Cup-likes: Cups	10 000909	Parent name updated & Changed name: was 'Cups and alikes'
10 000920	Sponges: Cup-likes: Cups: Tables / discs	10 000910	Moved is now subcategory under 10000910, changed name: was 'Tabular'
10 000919	Sponges: Cup-likes: Cups: Cup / goblet	10 000910	Parent name updated
10 000918	Sponges: Cup-likes: Cups: Incomplete cup / curled fan	10 000910	Parent name updated
10 000907	Sponges: Cup-likes: Barrels	10 000909	Parent name updated
10 000911	Sponges: Cup-likes: Tubes and chimneys	10 000909	Parent name updated

3. CATAMI classification scheme

The classification scheme was designed to allow images from shallow waters to abyssal depths and from the tropics to Antarctic waters to be classified using the same labels, i.e. a set of consistent identifiers. Each standardised label was also assigned a CAAB 'code'. CAAB stands for Codes for Australian Aquatic Biota and is a numerical code that is listed, described and maintained through a CSIRO website at (http://www.cmar.csiro.au/caab/).

Additional codes were necessary to indicate where a point/ image was not considered by the scorer (might have been missed or simply not yet labelled), is unscorable because of e.g. lighting issues or image quality, was not of interest to the current scorer (i.e. deliberately not considered) or had no visible biota. For data-basing purposes these scores needed a numeric, 8-digit code mimicking the published CAAB. In the CATAMI database the following codes are used:

Not considered CAAB 00 000000

Unscorable	CAAB 00 000001
Not of interest	CAAB 00 000002
No visible biota	CAAB 00 000003

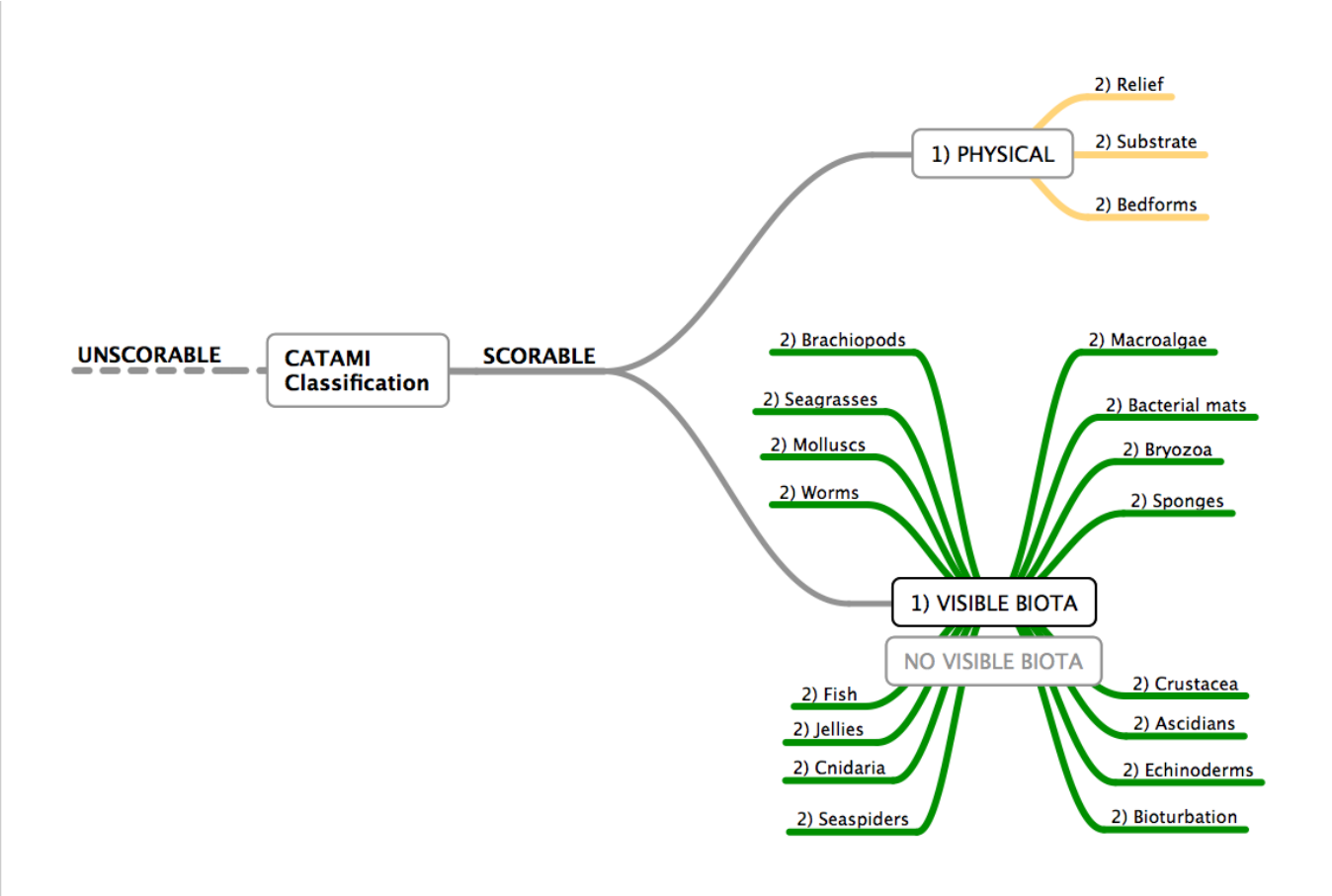

Figure 1: High level overview of the CATAMI classification scheme. Numbers indicate 1st level of hierarchy (1) or second (2). To view lower levels of the hierarchy refer to Appendix A and Figure 2.

3.1 Visible Biota

In images only visible biota (epiflora and epifauna) or visible traces of biota (bioturbation) can be reliably detected, thus the presence / absence of visible biota is at the highest level of the hierarchy. The second level of the hierarchy is mostly based on phylogeny, with Bioturbation, Bacterial mats, 'Jellies' and 'Worms' forming the obvious exceptions. 'Jellies' is a catch-all grouping of gelatinous fauna including siphonophores, jellyfish, sapls, etc.; 'Worms' refer to worm-like fauna, including several groups such as peanut-, spoon-, segmented-, flat-, acorn- and penis worms. As mentioned above the taxonomic classification within some taxa relies on fine-scale details that cannot easily be distinguished in imagery. For those taxa - Macroalgae, Sponges, Bryozoa, Cnidaria and Ascidians - the classification is based on morphological characteristics. For a detailed list of the entire classification refer to Appendix A or the 'explodagram'

3.2 Physical (Substrata)

The physical appearance of the seabed can be described based on the appearance of the substrata and based on the structure of the seabed (bedform and relief), using the

classification outlined below (Figure 2 / Table 1). Note that the 'Relief' category would be superseded by more detailed information such as multibeam acquisition and may only be useful to imagery obtained without this. In addition, wave height (> 10 cm) applies only to this image classification scheme and should not be used in other capacities. Note that from a geological perspective, waves are generally considered far larger but are confined here to anything >10 cm due to the comparatively small field of view of most underwater imaging systems.

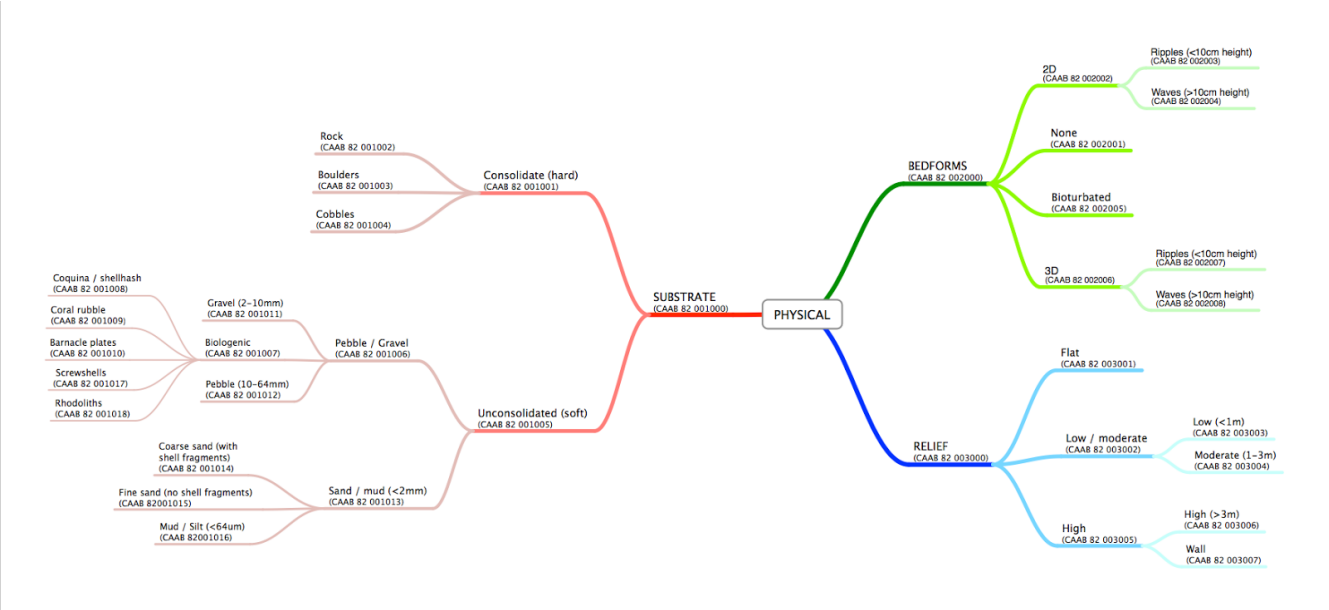

Figure 2: CATAMI Physical Classification showing all hierarchy levels.

CATAMI CAAB CODE	CATAMI DISPLAY NAME	CATAMI CAAB PARENT CODE	CPCe CODE
82 002000	Bedforms	82 000000	B
82 002002	Bedforms: 2D	82 002000	B2
82 002003	Bedforms: 2D: Ripples (<10cm height)	82 002002	B2R
82 002004	Bedforms: 2D: Waves (>10cm height)	82 002002	B2W
82 002006	Bedforms: 3D	82 002000	B3
82 002007	Bedforms: 3D: Ripples (<10cm height)	82 002006	B3R
82 002008	Bedforms: 3D: Waves (>10cm height)	82 002006	B3W
82 002005	Bedforms: Bioturbated	82 002000	BB
82 002001	Bedforms: None	82 002000	BN
82 000000	Physical		
82 003000	Relief	82 000000	R
82 003001	Relief: Flat	82 003000	RF
82 003005	Relief: High	82 003000	RH
82 003006	Relief: High: High (>3m)	82 003005	RHH

82 003007	Relief: High: Wall	82 003005	RHR
82 003002	Relief: Low / moderate	82 003000	RL
82 003003	Relief: Low / moderate: Low (<1m)	82 003002	RLL
82 003004	Relief: Low / moderate: Moderate (1-3m)	82 003002	RLM
82 001000	Substrate	82 000000	S
82 001001	Substrate: Consolidated (hard)	82 001000	SC
82 001003	Substrate: Consolidated (hard): Boulders	82 001001	SCB
82 001004	Substrate: Consolidated (hard): Cobbles	82 001001	SCC
82 001002	Substrate: Consolidated (hard): Rock	82 001001	SCR
82 001005	Substrate: Unconsolidated (soft)	82 001000	SU
82 001006	Substrate: Unconsolidated (soft): Pebble / gravel	82 001005	SUP
82 001007	Substrate: Unconsolidated (soft): Pebble / gravel: Biologenic	82 001006	SUPB
82 001010	Substrate: Unconsolidated (soft): Pebble / gravel: Biologenic: Barnacle plates	82 001007	SUPBB
82 001008	Substrate: Unconsolidated (soft): Pebble / gravel: Biologenic: Coquina / shellhash	82 001007	SUPBC
82 001009	Substrate: Unconsolidated (soft): Pebble / gravel: Biologenic: Coral rubble	82 001007	SUPBR
82 001018	Substrate: Unconsolidated (soft): Pebble / gravel: Biologenic: Rhodoliths	82 001007	SUPBR
82 001017	Substrate: Unconsolidated (soft): Pebble / gravel: Biologenic: Screwshells	82 001007	SUPBS
82 001011	Substrate: Unconsolidated (soft): Pebble / gravel: Gravel (2-10mm)	82 001006	SUPG
82 001012	Substrate: Unconsolidated (soft): Pebble / gravel: Pebble (10-64mm)	82 001006	SUPP
82 001013	Substrate: Unconsolidated (soft): Sand / mud (<2mm)	82 001005	SUS
82 001014	Substrate: Unconsolidated (soft): Sand / mud (<2mm): Coarse sand (with shell fragments)	82 001013	SUSC
82 001015	Substrate: Unconsolidated (soft): Sand / mud (<2mm): Fine sand (no shell fragments)	82 001013	SUSF
82 001016	Substrate: Unconsolidated (soft): Sand / mud (<2mm): Mud / silt (<64um)	82 001013	SUSM

Table 1: List of CAAB codes assigned to CATAMI Physical Classification

3.3 Qualifiers

Below are a list of "qualifiers" for the CATAMI standardised classifications. These are standardised descriptors of biota or physical characters that provide useful additional information for later analyses and comparisons by researchers. This is a controlled list, in

order to facilitate database searches, which can be amended if appropriate. For most up-to-date list visit: https://github.com/catami/catami/wiki/Qualifiers

Natural
- 'Bleached'
- 'Dead'
- 'Storm damage'
- 'Urchin barren'
- 'Iceberg scour'
- 'Veneer'
- 'Epiphyte'
- 'Rhodolith' *(for algae -> crustose / prostrate -> red)*
- 'Recruits'

Anthropogenic
- 'Rubbish - Concentrated' *(e.g. dumpsite)*
- 'Rubbish - Occasional' *(e.g. car tyre)*
- 'Rubbish - Shipwreck'
- 'Fishery related - Gear tracks / marks'
- 'Fishery related - Damage to solid epifauna',
- 'Fishery related - Discarded / lost gear'

Level (default is primary)
- 'Primary' = organism on the seafloor (e.g. urchin on sand)
- 'Secondary' = raised above the seabed and obstructing view of the understory (e.g. algae frond).
- 'Tertiary' = sitting on a primary or secondary organisms (i.e. urchin on an algae frond)

Whole-image classification
Using the CATAMI classification, researchers can classify the image 'as a whole' according to *dominant* biota and/or *dominant* substrata / bedform / relief. Where biota is sparse, the *dominant* biota may not cover much of the image; thus, a qualifier can be added to indicate the percentage of the field of view (FOV) covered by the dominant biota. This scale was deliberately chosen to keep things manageable, other schemes such as SACFOR scale relate to 'finer / detailed' scoring which can be accomplished using the CATAMI classification scheme labels via a number of different methodologies (e.g. random point counts in CPCe or CATAMI online annotation tool).

- '<20% FOV'
- '20-40% FOV'
- '40-60% FOV'
- '60-80% FOV'
- '>80% FOV'

For example
- *Visible Biota* | *Sponges (Porifera)* | *Massive* | >80%
- *Visible Biota* | *Cnidaria* | *Coral* | *Stony Coral*
- *Visible Biota* | *Cnidaria* | *Coral* | *Stony Coral (Bleached)*

- *Visible Biota | Cnidaria | Coral | Stony Coral (Dead)*
- *Physical | Consolidate (hard) | Rock*
- *Physical | Consolidate (hard) | Rock (Occasional)*
- *Physical | Consolidate (hard) | Boulders (Urchin barren)*
- *Physical | Unconsolidated (soft) | Sand (Veneer)*

3.4 Methodology / Tools

In addition to having labels for biota and physical characteristics it is important to consider the tools used to collect imagery and the methods used to score them. The development of tools for image acquisition in marine environments is a very active area and it would be short-sighted to try and be prescriptive about how imagery is collected. Similarly methods for annotating and scoring images tend to reflect the research question being addressed and potential limitations of the collection method, and thus are tailored in the approach (random point counts, densities, overview) and level of detail (e.g. species identification but only of macroalgae, or phylum-level identification of everything), rather than follow an overarching set-out protocol. Although separate to the classification, this information is important if researchers wish to incorporate scored data into CATAMI to be potentially used by other researchers.

When creating a “campaign” in CATAMI, users are asked to provide “publications”, this is a suitable location to provide links to papers / reports which detail methodology in greater detail. In addition, collection or scoring method (with standardised high-level categories) should be filled in to facilitate database searching and selection based on methods. Having high level methodology categories are useful for aggregating data into CATAMI. This will assist in comparison along with the specific methodology used. Having this information in the CATAMI database will be useful to flag future comparison and analysis of data.

High level methodology categories

1. Point Counts (e.g. CPCe - Coral Point Count)
2. Relative abundance
3. Quadrats (e.g. Williams et al., 2010; Rowden et al.,2010)
4. Point of change (e.g. Williams et al., 2009; Althaus et al., 2009)
5. Real-time fixed window (e.g. Anderson et. al. 2007)

High-level collection tool categories

1. BRUV (Baited Remote Underwater Video) / (SISSTAs) Stereo Imagery System for Shark and Tuna Analysis
2. AUV (Autonomous Underwater Vehicle)
3. Towed / tethered system
4. Diver based (e.g. DOV - Diver Operated Video / Photo quadrats)
5. ROV (Remote Operated Vehicle)
6. Manned vehicle

Qualifiers for the 6 high-level collection tool categories are:

- **View angle** [planar (vertical / downward) or slanting (oblique) or seascape (horizontal)]
- **Camera set-up** [stereo or mono]; [if stereo calibrated or not]
- **Image type** [still images, mosaic (e.g. AUV), HD video stream, PAL]
- **Precision of location** [how camera position is derived (USBL beacon, triangulation, ship location)]

4. Implementation

When developing this classification it was identified early on that there needed to be an easy method for researchers to use and incorporate into their workflows. Listed below are methods for interacting with this classification. A guide to the classification has also been developed which will contains example photos and descriptions for the entire classification scheme (Althaus et al. 2013). Please refer to the following wiki for the most up-to-date information. The CAAB website will also contain this information to aid researchers in scoring imagery.

a) Integration with CAAB

CAAB is a managed and expanding 8-digit coding system for aquatic organisms in the Australian region maintained by CSIRO Division of Marine and Atmospheric Research, Australia (CMAR). CAAB are being expanded to incorporate the CATAMI classification morphology types. This will aid implementation as many researchers are already familiar and use CAAB through their existing workflows. This also assists in sustainability as the 'point of truth' database will reside at CSIRO which is an established organisation rather than a project. Having this security will provide researchers with a level of confidence to use the classification.

b) Cross-walk existing classifications

When developing the classification it was acknowledged that for a variety of reasons organisations would not be able to switch to the CATAMI classification, at least initially. The CATAMI team will work with relevant organisations who wish to share their data to ensure their 'in-house' classifications map correctly to the CATAMI classification and will provide standard templates to import data. An example is the creation of a CATAMI-CPC code file so researchers using the CPC software to annotate images can use the CATAMI classification scheme and then import into CATAMI. To assist researchers CPC codes are given in this document, further information is available from Kohler and Gill (2006).

c) CATAMI online interface

Researchers will be able to score and browse using this classification via the CATAMI online interface as it becomes fully functional (http://catami.org).

5. Acknowledgments

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References

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Appendix A: CATAMI Biota CAAB codes

CATAMI	CATAMI DISPLAY NAME	CATAMI CAAB	CPC

CAAB CODE		PARENT CODE	CODE
35 000000	Ascidians	80 000000	A
35 000904	Ascidians: Stalked	35 000000	AS
35 000906	Ascidians: Stalked: Colonial	35 000904	ASC
35 000905	Ascidians: Stalked: Solitary	35 000904	ASS
35 000901	Ascidians: Unstalked	35 000000	AU
35 000903	Ascidians: Unstalked: Colonial	35 000901	AUC
35 000902	Ascidians: Unstalked: Solitary	35 000901	AUS
72 000901	Bacterial mats	80 000000	BM
70 000901	Bacterial mats: Cyanobacteria	72 000901	BMC
72 000902	Bacterial mats: Other	72 000901	BMO
80 000000	Biota		BIOTA
81 000000	Bioturbation	80 000000	BI
81 005000	Bioturbation: Crawling traces	81 000000	BIC
81 005003	Bioturbation: Crawling traces: Complex trail	81 005000	BICCT
81 005006	Bioturbation: Crawling traces: Crater row	81 005000	BICCR
81 005007	Bioturbation: Crawling traces: Disturbed trace	81 005000	BICD
81 005004	Bioturbation: Crawling traces: Mounded trail	81 005000	BICM
81 005005	Bioturbation: Crawling traces: Perforated trail	81 005000	BICP
81 005002	Bioturbation: Crawling traces: Thick trail	81 005000	BICTK
81 005001	Bioturbation: Crawling traces: Thin trail	81 005000	BICTN
81 001000	Bioturbation: Dwelling traces	81 000000	BID
81 001004	Bioturbation: Dwelling traces: Burrow cluster	81 001000	BIDB
81 001012	Bioturbation: Dwelling traces: Crater cone	81 001000	BIDC
81 001001	Bioturbation: Dwelling traces: Elongate depression	81 001000	BIDE
81 001013	Bioturbation: Dwelling traces: Fractured mound	81 001000	BIDF
81 001002	Bioturbation: Dwelling traces: Large mound	81 001000	BIDL
81 001005	Bioturbation: Dwelling traces: Oblique burrow	81 001000	BIDO
81 001007	Bioturbation: Dwelling traces: Paired burrow	81 001000	BIDP
81 001010	Bioturbation: Dwelling traces: Rounded crater ring	81 001000	BIDR
81 001006	Bioturbation: Dwelling traces: Single burrow	81 001000	BIDSB
81 001003	Bioturbation: Dwelling traces: Small mound	81 001000	BIDSM
81 001011	Bioturbation: Dwelling traces: Spiked crater ring	81 001000	BIDSC

81 001014	Bioturbation: Dwelling traces: Spotted mound	81 001000	BIDSP
81 001009	Bioturbation: Dwelling traces: Trapdoor burrow	81 001000	BIDT
81 001008	Bioturbation: Dwelling traces: Vertical burrow	81 001000	BIDV
81 004000	Bioturbation: Feeding traces	81 000000	BIF
81 004001	Bioturbation: Feeding traces: Large rosette	81 004000	BIFL
81 004003	Bioturbation: Feeding traces: Petal rosette	81 004000	BIFPE
81 004005	Bioturbation: Feeding traces: Pincushion rosette	81 004000	BIFPI
81 004004	Bioturbation: Feeding traces: Rayed mound	81 004000	BIFR
81 004002	Bioturbation: Feeding traces: Small rosette	81 004000	BIFS
81 006000	Bioturbation: Organism tests	81 000000	BIO
81 006002	Bioturbation: Organism tests: Globule xenophyophore	81 006000	BIOG
81 006001	Bioturbation: Organism tests: Lumpy xenophyophore	81 006000	BIOL
81 003000	Bioturbation: Resting traces	81 000000	BIR
81 003003	Bioturbation: Resting traces: Large depression	81 003000	BIRL
81 003002	Bioturbation: Resting traces: Star impression	81 003000	BIRS
81 003001	Bioturbation: Resting traces: Urchin trace	81 003000	BIRU
81 007000	Bioturbation: Unknown origin	81 000000	BIU
81 007006	Bioturbation: Unknown origin: Fern	81 007000	BIUF
81 007005	Bioturbation: Unknown origin: Matchstick	81 007000	BIUMA
81 007003	Bioturbation: Unknown origin: Mesh	81 007000	BIUME
81 007001	Bioturbation: Unknown origin: Ovoid pinnate	81 007000	BIUO
81 007007	Bioturbation: Unknown origin: Pogostick	81 007000	BIUP
81 007002	Bioturbation: Unknown origin: Round pinnate	81 007000	BIUR
81 007004	Bioturbation: Unknown origin: Spider	81 007000	BIUS
81 002000	Bioturbation: Waste casts	81 000000	BIW
81 002001	Bioturbation: Waste casts: Coiled casts	81 002000	BIWCO
81 002005	Bioturbation: Waste casts: Curly casts	81 002000	BIWCU
81 002004	Bioturbation: Waste casts: Mounded casts	81 002000	BIWM
81 002006	Bioturbation: Waste casts: Nest casts	81 002000	BIWN
81 002003	Bioturbation: Waste casts: Round casts	81 002000	BIWR
81 002007	Bioturbation: Waste casts: Spirals	81 002000	BIWSP
81 002008	Bioturbation: Waste casts: Switchbacks	81 002000	BIWSW
81 002002	Bioturbation: Waste casts: Wavy casts	81 002000	BIWW

19 100000	Brachiopods	80 000000	BRA
20 000000	Bryozoa	80 000000	BRY
20 000901	Bryozoa: Hard	20 000000	BRYH
20 000908	Bryozoa: Hard: Branching	20 000901	BRYHB
20 000902	Bryozoa: Hard: Encrusting	20 000901	BRYHE
20 000903	Bryozoa: Hard: Fenestrate	20 000901	BRYHF
20 000904	Bryozoa: Hard: Massive	20 000901	BRYHM
20 000905	Bryozoa: Soft	20 000000	BRYS
20 000906	Bryozoa: Soft: Dendroid	20 000905	BRYSD
20 000907	Bryozoa: Soft: Foliaceous	20 000905	BRYSF
11 500000	Cnidaria	80 000000	CN
11 500901	Cnidaria: Colonial anemones	11 500000	CNCA
11 280000	Cnidaria: Colonial anemones: Corallimorphs	11 500901	CNCAC
11 284000	Cnidaria: Colonial anemones: Zoanthids	11 500901	CNCAZ
11 168000	Cnidaria: Corals	11 500000	C
11 168901	Cnidaria: Corals: Black & Octocorals	11 168000	CB
11 171000	Cnidaria: Corals: Black & Octocorals: Blue coral (Heliopora)	11 168901	CBBH
11 168902	Cnidaria: Corals: Black & Octocorals: Branching (3D)	11 168901	CBB
11 168909	Cnidaria: Corals: Black & Octocorals: Branching (3D): Fleshy	11 168902	CBBF
11 168911	Cnidaria: Corals: Black & Octocorals: Branching (3D): Fleshy: Arborescent	11 168909	CBBFA
11 168910	Cnidaria: Corals: Black & Octocorals: Branching (3D): Fleshy: Mushroom	11 168909	CBBFM
11 168903	Cnidaria: Corals: Black & Octocorals: Branching (3D): Non-fleshy	11 168902	CBBN
11 168904	Cnidaria: Corals: Black & Octocorals: Branching (3D): Non-fleshy: Arborescent	11 168903	CBBNA
11 168905	Cnidaria: Corals: Black & Octocorals: Branching (3D): Non-fleshy: Bottle-brush	11 168903	CBNB
11 168907	Cnidaria: Corals: Black & Octocorals: Branching (3D): Non-fleshy: Bottle-brush: Complex	11 168905	CBNBC
11 168906	Cnidaria: Corals: Black & Octocorals: Branching (3D): Non-fleshy: Bottle-brush: Simple	11 168905	CBNBS
11 168908	Cnidaria: Corals: Black & Octocorals: Branching (3D): Non-fleshy: Bushy	11 168903	CBNBU
11 168919	Cnidaria: Corals: Black & Octocorals: Encrusting	11 168901	CBE
11 168912	Cnidaria: Corals: Black & Octocorals: Fan (2D)	11 168901	CBF

11 168913	Cnidaria: Corals: Black & Octocorals: Fan (2D): Fern-frond	11 168912	CBFF
11 168915	Cnidaria: Corals: Black & Octocorals: Fan (2D): Fern-frond: Complex	11 168913	CBFFC
11 168914	Cnidaria: Corals: Black & Octocorals: Fan (2D): Fern-frond: Simple	11 168913	CBFFS
11 168916	Cnidaria: Corals: Black & Octocorals: Fan (2D): Rigid	11 168912	CBFR
11 168920	Cnidaria: Corals: Black & Octocorals: Massive soft corals	11 168901	CBM
11 201901	Cnidaria: Corals: Black & Octocorals: Organ pipe coral (Tubipora)	11 168901	CBOT
11 168918	Cnidaria: Corals: Black & Octocorals: Quill (seapen)	11 168901	CBQ
11 168917	Cnidaria: Corals: Black & Octocorals: Whip	11 168901	CBW
11 290000	Cnidaria: Corals: Stony corals	11 168000	CS
11 290904	Cnidaria: Corals: Stony corals: Bottlebrush	11 290000	CSBO
11 290912	Cnidaria: Corals: Stony corals: Branching	11 290000	CSBR
11 290915	Cnidaria: Corals: Stony corals: Columnar	11 290000	CSCOL
11 290910	Cnidaria: Corals: Stony corals: Corymbose	11 290000	CSCOR
11 290909	Cnidaria: Corals: Stony corals: Digitate	11 290000	CSD
11 290908	Cnidaria: Corals: Stony corals: Encrusting	11 290000	CSE
11 290907	Cnidaria: Corals: Stony corals: Foliose / plate	11 290000	CSF
11 290906	Cnidaria: Corals: Stony corals: Massive	11 290000	CSM
11 290901	Cnidaria: Corals: Stony corals: Solitary	11 290000	CSSO
11 290903	Cnidaria: Corals: Stony corals: Solitary: Attached	11 290901	CSSOA
11 290902	Cnidaria: Corals: Stony corals: Solitary: Free-living	11 290901	CSSOF
11 298000	Cnidaria: Corals: Stony corals: Solitary: Mushroom (Fungiidae)	11 290901	CSSOM
11 290913	Cnidaria: Corals: Stony corals: Staghorn	11 290000	CSST
11 290905	Cnidaria: Corals: Stony corals: Sub-massive	11 290000	CSSU
11 290911	Cnidaria: Corals: Stony corals: Tabulate	11 290000	CST
11 077000	Cnidaria: Hydrocorals	11 500000	CNHYC
11 077906	Cnidaria: Hydrocorals: Branching	11 077000	CNHYCB
11 077907	Cnidaria: Hydrocorals: Submassive / encrusting	11 077000	CNHYCS
11 001000	Cnidaria: Hydroids	11 500000	CNHYD
11 229000	Cnidaria: True anemones	11 500000	CNTR
11 229901	Cnidaria: True anemones: Flytrap	11 229000	CNTFT

11 229902	Cnidaria: True anemones: Fourlobed	11 229000	CNTFL
11 229903	Cnidaria: True anemones: Other anemones	11 229000	CNTRO
11 164000	Cnidaria: Tube anemones	11 500000	CNTU
27 000000	Crustacea	80 000000	CR
27 500000	Crustacea: Barnacles	27 000000	CRB
27 500902	Crustacea: Barnacles: Acorn	27 500000	CRBA
27 500901	Crustacea: Barnacles: Stalked	27 500000	CRBS
28 000903	Crustacea: Crabs	27 000000	CRC
28 836000	Crustacea: Crabs: King crabs	28 000903	CRCK
28 843000	Crustacea: Crabs: Porcelain crabs	28 000903	CRCP
28 850000	Crustacea: Crabs: True crabs	28 000903	CRCT
28 825901	Crustacea: Hermit crabs	27 000000	CRH
28 825902	Crustacea: Hermit crabs: With shell or stone home	28 825901	CRHWZ
28 825903	Crustacea: Hermit crabs: With anemones	28 825901	CRHGS
28 000902	Crustacea: Lobsters	27 000000	CRL
28 820000	Crustacea: Lobsters: Rock lobsters	28 000902	CRLR
28 821000	Crustacea: Lobsters: Slipper lobsters / bugs	28 000902	CRLSL
28 825904	Crustacea: Lobsters: Squat lobsters	28 000902	CRLSQ
28 786000	Crustacea: Lobsters: True lobsters	28 000902	CRLT
28 000901	Crustacea: Prawns / shrimps / mysids	27 000000	CRP
25 000000	Echinoderms	80 000000	E
25 001000	Echinoderms: Feather stars	25 000000	EF
25 001901	Echinoderms: Feather stars: Stalked crinoids	25 001000	EFS
25 001902	Echinoderms: Feather stars: Unstalked crinoids	25 001000	EFU
25 160000	Echinoderms: Ophiuroids	25 000000	EO
25 160902	Echinoderms: Ophiuroids: Basket stars	25 160000	EOBS
25 160901	Echinoderms: Ophiuroids: Brittle / snake stars	25 160000	EOBSS
25 400000	Echinoderms: Sea cucumbers	25 000000	ESC
25 400901	Echinoderms: Sea cucumbers: Benthic	25 400000	ESCB
25 400902	Echinoderms: Sea cucumbers: Pelagic / swimming	25 400000	ESCP
25 102000	Echinoderms: Sea stars	25 000000	ESS
25 200000	Echinoderms: Sea urchins	25 000000	ESU
25 200902	Echinoderms: Sea urchins: Irregular urchins	25 200000	ESUI

25 200901	Echinoderms: Sea urchins: Regular urchins	25 200000	ESUR
37 000000	Fishes	80 000000	F
37 990083	Fishes: Bony fishes	37 000000	FB
37 990025	Fishes: Eels	37 000000	FEE
37 990082	Fishes: Elasmobranchs	37 000000	FEL
37 990028	Fishes: Elasmobranchs: Chimaeras	37 990082	FELC
37 990030	Fishes: Elasmobranchs: Rays & skates	37 990082	FELR
37 990016	Fishes: Elasmobranchs: Sharks	37 990082	FELS
80 600903	Jellies	80 000000	J
12 000000	Jellies: Ctenophores	80 600903	JCT
11 150000	Jellies: Cubozoa	80 600903	JCU
11 000901	Jellies: Hydromedusae	80 600903	JH
35 101000	Jellies: Pyrosomes	80 600903	JP
35 100000	Jellies: Salps	80 600903	JSA
11 120000	Jellies: Scyphozoa	80 600903	JSC
11 090000	Jellies: Siphonophores	80 600903	JSI
80 300000	Macroalgae	80 000000	MA
80 300911	Macroalgae: Articulated calcareous	80 300000	MAA
80 300912	Macroalgae: Articulated calcareous: Green	80 300911	MAAG
80 300913	Macroalgae: Articulated calcareous: Red	80 300911	MAAR
80 300926	Macroalgae: Encrusting	80 300000	MAEN
80 300927	Macroalgae: Encrusting: Brown	80 300926	MAENB
80 300928	Macroalgae: Encrusting: Green	80 300926	MAENG
80 300929	Macroalgae: Encrusting: Red	80 300926	MAENR
80 300934	Macroalgae: Encrusting: Red: Calcareous	80 300929	MAENRC
80 300935	Macroalgae: Encrusting: Red: Non-calcareous	80 300929	MEANRNC
80 300903	Macroalgae: Erect coarse branching	80 300000	MAEC
80 300904	Macroalgae: Erect coarse branching: Brown	80 300903	MAECB
80 300905	Macroalgae: Erect coarse branching: Green	80 300903	MAECG
80 300906	Macroalgae: Erect coarse branching: Red	80 300903	MAECR
80 300907	Macroalgae: Erect fine branching	80 300000	MAEF
80 300908	Macroalgae: Erect fine branching: Brown	80 300907	MAEFB
80 300909	Macroalgae: Erect fine branching: Green	80 300907	MAEFG

80 300910	Macroalgae: Erect fine branching: Red	80 300907	MAEFR
80 300930	Macroalgae: Filamentous / filiform	80 300000	MAF
80 300931	Macroalgae: Filamentous / filiform: Brown	80 300930	MAFB
80 300932	Macroalgae: Filamentous / filiform: Green	80 300930	MAFG
80 300933	Macroalgae: Filamentous / filiform: Red	80 300930	MAFR
80 300914	Macroalgae: Globose / saccate	80 300000	MAG
80 300915	Macroalgae: Globose / saccate: Brown	80 300914	MAGB
80 300916	Macroalgae: Globose / saccate: Green	80 300914	MAGG
80 300917	Macroalgae: Globose / saccate: Red	80 300914	MAGR
80 300918	Macroalgae: Laminate	80 300000	MALA
80 300919	Macroalgae: Laminate: Brown	80 300918	MALAB
80 300920	Macroalgae: Laminate: Green	80 300918	MALAG
80 300921	Macroalgae: Laminate: Red	80 300918	MALAR
80 300901	Macroalgae: Large canopy-forming	80 300000	MALC
80 300902	Macroalgae: Large canopy-forming: Brown	80 300901	MALCB
80 300922	Macroalgae: Sheet-like / membraneous	80 300000	MAS
80 300923	Macroalgae: Sheet-like / membraneous: Brown	80 300922	MASB
80 300924	Macroalgae: Sheet-like / membraneous: Green	80 300922	MASG
80 300925	Macroalgae: Sheet-like / membraneous: Red	80 300922	MASR
23 000000	Molluscs	80 000000	MO
23 199000	Molluscs: Bivalves	23 000000	MOB
23 590000	Molluscs: Cephalopods	23 000000	MOCE
23 607000	Molluscs: Cephalopods: Cuttlefish	23 590000	MOCEC
23 650000	Molluscs: Cephalopods: Octopods	23 590000	MOCEO
23 615000	Molluscs: Cephalopods: Squid	23 590000	MOCES
23 100000	Molluscs: Chitons	23 000000	MOCH
24 000000	Molluscs: Gastropods	23 000000	MOG
33 000000	Sea spiders	80 000000	SS
63 600901	Seagrasses	80 000000	SEAG
63 600902	Seagrasses: Elliptical leaves	63 600901	SEAGE
63 600903	Seagrasses: Strap-like leaves	63 600901	SEAGS
10 000000	Sponges	80 000000	SP
10 000901	Sponges: Crusts	10 000000	SPC

10 000917	Sponges: Crusts: Creeping / ramose	10 000901	SPCCR
10 000902	Sponges: Crusts: Encrusting	10 000901	SPCE
10 000921	Sponges: Crusts: Endolithic / bioeroding	10 000901	SPCEB
10 000909	Sponges: Cup-likes	10 000000	SPCL
10 000907	Sponges: Cup-likes: Barrels	10 000909	SPCLB
10 000910	Sponges: Cup-likes: Cups	10 000909	SPCLC
10 000919	Sponges: Cup-likes: Cups: Cup / goblet	10 000910	SPCLCG
10 000918	Sponges: Cup-likes: Cups: Incomplete cup / curled fan	10 000910	SPCLCI
10 000920	Sponges: Cup-likes: Cups: Tables / discs	10 000910	SPCLCT
10 000911	Sponges: Cup-likes: Tubes and chimneys	10 000909	SPCLTC
10 000912	Sponges: Erect forms	10 000000	SPE
10 000915	Sponges: Erect forms: Branching	10 000912	SPEB
10 000913	Sponges: Erect forms: Laminar	10 000912	SPEL
10 000914	Sponges: Erect forms: Palmate	10 000912	SPEP
10 000916	Sponges: Erect forms: Simple	10 000912	SPES
10 000906	Sponges: Erect forms: Stalked	10 000912	SPMST
10 000903	Sponges: Massive forms	10 000000	SPM
10 000905	Sponges: Massive forms: Balls	10 000903	SPMR
10 000908	Sponges: Massive forms: Cryptic	10 000903	SPMC
10 000904	Sponges: Massive forms: Simple	10 000903	SPMSI
80 600901	Worms	80 000000	W
36 110000	Worms: Acorn worms	80 600901	WA
17 020000	Worms: Echiura	80 600901	WEE
13 000000	Worms: Flatworms	80 600901	WF
15 400000	Worms: Penisworms	80 600901	WPE
22 000000	Worms: Polychaetes	80 600901	WPO
22 000902	Worms: Polychaetes: Other polychaetes	22 000000	WPOO
22 000901	Worms: Polychaetes: Tube worms	22 000000	WPOT
17 000000	Worms: Sipuncula	80 600901	WES