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DATA DESCRIPTOR

The Antarctic Seafloor Annotated Imagery Database

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Marine imagery can be a comparatively cost-effective way to collect data on seafloor organisms, biodiversity and habitat morphology. However, annotating these images to extract detailed biological information is time-consuming and expensive, and reference libraries of consistently annotated seafloor images are rarely publicly available. Here, we present the Antarctic Seafloor Annotated Imagery Database (AS-AID), a result of a multinational collaboration to collate and annotate seafloor imagery datasets from 21 Antarctic research campaigns between 1985 and 2019. AS-AID is comprised of 52,491 georeferenced downward facing seafloor images of which 3,599 have been labelled with a total of 632,252 expert annotations. Annotations are based on the Collaborative and Automated Tools for Analysis of Marine Imagery (CATAMI) classification scheme and have been reviewed by experts. In addition, because the pixel location of each annotation within each image is available, annotations can be viewed easily and customised to suit individual research priorities. This dataset can be used to investigate species distributions, community patterns, provide a reference to assess change through time, and can be used to train algorithms to automatically detect and annotate marine fauna.

Background & Summary

Marine imagery can be a cost-effective and non-destructive way to gather information about the seafloor[1]. Extracting detailed and high-quality biological information from these images, however, is a key bottleneck because image annotation is time-consuming and often expensive. Perhaps because these data are difficult to produce, they have historically rarely been shared on public repositories. There has been a recent societal and scientific shift towards sharing data, greater transparency and reproducibility of data (FAIR data principles)[2,3], and increasing capabilities of machine learning methods that require large numbers of annotated images has encouraged more scientists and research institutions to make datasets of expert annotated marine images publicly available (e.g., FathomNet[4], BenthOZ-2015[5]). Nonetheless, for most regions around the world, including the Southern Ocean, expert annotated seafloor images are rarely publicly available.

The sparsity of biological data has impeded efforts to benchmark the status of marine ecosystems, and therefore also prevents monitoring of ecological change. This is particularly evident for the highly biodiverse Antarctic seafloor[6–8], which still lacks a comprehensive analysis of the distribution of its biodiversity on a continental scale. A database of the distribution and abundances of a broad range of organisms covering the entire Antarctic continental shelf is invaluable to help identify key conservation areas and manage these unique ecosystems.

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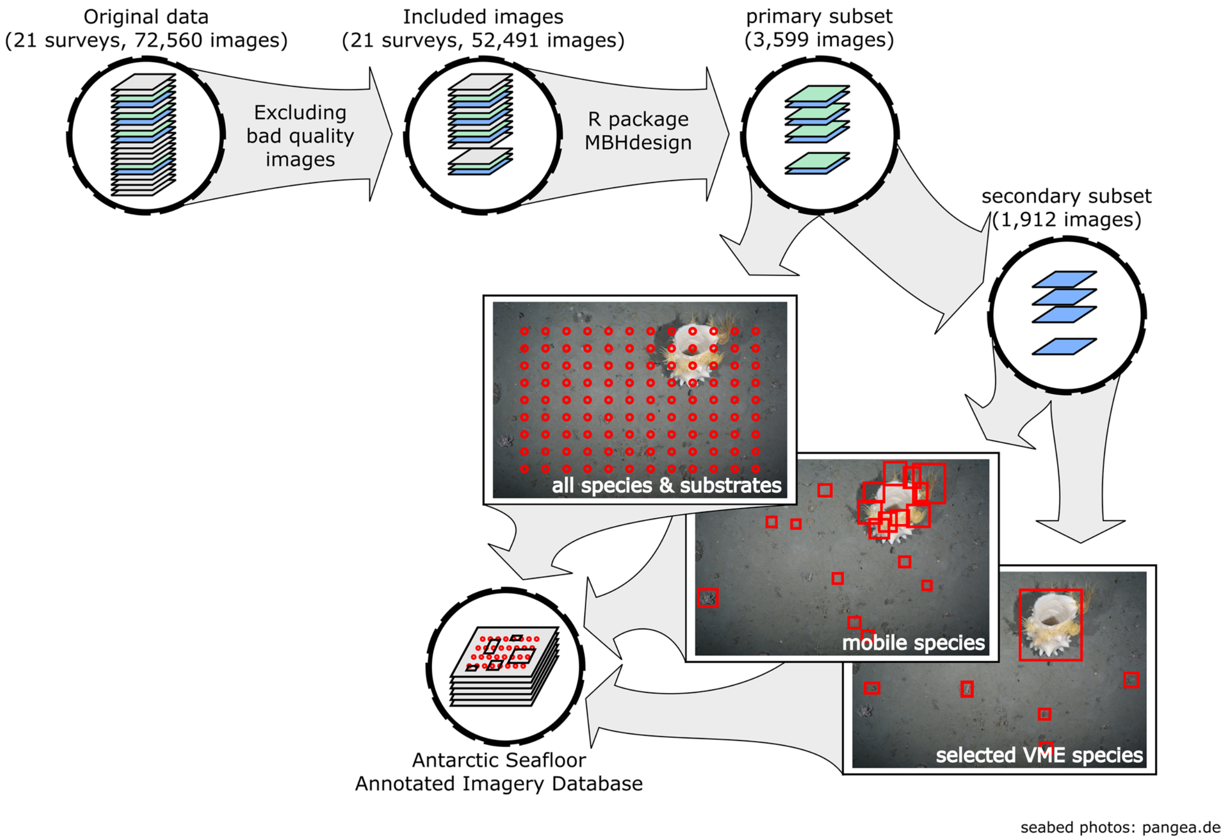

Fig. 1 Simple overview of the steps involved in building AS-AID, including the methodology used to generate the database. See methods section for more details. Seabed photo sourced from pangea.de.

In this data descriptor, we introduce a database of expert annotated seafloor imagery from the Antarctic continental shelf and slope, the Antarctic Seafloor Annotated Imagery Database (AS-AID, Fig. 1). AS-AID is comprised of 52,491 images of which 3,599 are annotated with a total of 632,252 annotation-points and 174 faunal and substrate classifications. Images have been collected from research campaigns between 1985 and 2019 for which data was either publicly available or could be sourced by directly contacting data curators. This represents the first international effort to collate images from different regions of the Southern Ocean at a pan-Antarctic scale into a single database and annotate these images using a single classification scheme.

Repeatability is key to making data useful beyond the scope of a single project, which is why annotations in AS-AID are based on an internationally recognised standard for labelling marine images (CATAMI[9]), and all annotations have exact reference points (x and y coordinates) to their respective images. Users can view AS-AID annotations on Squidle+ (www.squidle.org) and review all annotations for a single label and customise annotation labels to suit their own research objective. AS-AID can be used to train deep learning algorithms for automated classification of marine fauna. Combining AS-AID with environmental data and statistical models can allow insights into the species distributions and ecological processes that shape Antarctic seafloor ecosystems[10–13].

Methods

The Antarctic Seafloor Annotated Image Database (AS-AID) includes downward facing images of the seafloor at a depth range between 0–3,307 m from Antarctic research campaigns for which we were able to obtain access to both images and detailed metadata records. We focussed annotations in the first iteration to images deeper than 100 m because at these depths environmental conditions are more stable (e.g., relatively less impact on the fauna from iceberg scour) and more comparable between regions, which suits the continental scale biodiversity analysis that this database has primarily been developed for. Further, and also in its first iteration, AS-AID focusses on downward facing seafloor imagery rather than oblique facing imagery (where cameras can be mounted at different angles) because initial work indicated that downward facing images are more comparable between different research campaigns, with greater uniformity of illumination and resolution. Additionally, the area of seabed imaged with downward facing cameras can be more accurately estimated than from data collected with obliquely mounted cameras. In total, we identified 21 research campaigns from 2019 and prior that collected downward facing images of suitable quality with accessible metadata records (Figs. 1, 2 & Table 1). The only

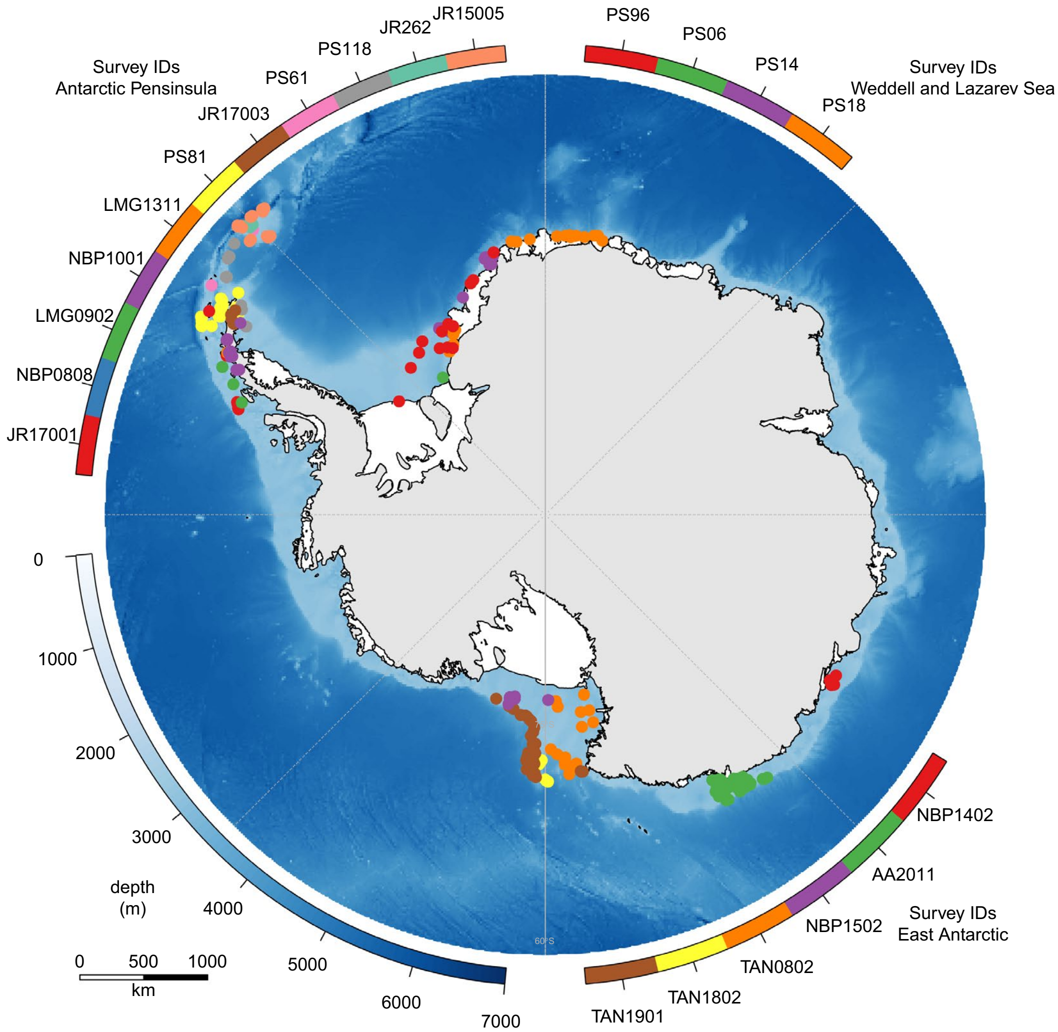

Fig. 2 Overview of the circum-Antarctic distribution of sampling locations, including which research campaign ("Survey ID") they originate from. More details on the individual research campaigns can be found in Tables 1–4.

research campaigns that we identified as potentially suitable, but for which we could not access all relevant data were LMG1703 and ANA08D, which are therefore excluded from AS-AID at time of writing. More relevant research campaigns potentially exist for this time-period, and will be included in future iterations if they are identified as suitable.

Sampling locations and image collection. AS-AID images were collected during 21 research campaigns between 1985 and 2019 (Tables 1–4), using a range of different camera platforms (Table 4). Figure 2 shows an overview of sampling locations for all image transects included in AS-AID. Images and metadata were downloaded and stored on external hard-drives, and image filenames were standardised for processing.

Image pre-processing. We inspected all 72,560 images visually and removed images/transects from AS-AID that were out of focus, too far or too close to the seafloor to allow identification of animals, had poor lighting, or had unreliable coordinates (Tables 2 & 3), resulting in 52,491 usable images. We then corrected images for tone, colour and contrast using the automated batch function in Adobe Photoshop Version 21 (all research campaigns apart from PS96, see Table 4). Further, because the corners of images from research campaigns PS81, PS96, PS118, AA2011 and NBP1402 are out of focus or badly illuminated we cropped these images to either 80% or 90% of their original size (Table 4).

Image sub-setting. Annotating all images from all research campaigns is neither feasible nor desirable due to the large differences in sampling effort among research campaigns (i.e., the density of images along the transect lines is highly variable). We therefore created a subset of the full dataset by selecting a spatially balanced random subset of the images using their coordinates and the distance along the transect line with the R package MBHdesign version 2.2.2. Where only one coordinate for the transect was available, or where recorded

Survey ID	Year	Region	Contact	Reference for dataset (if available)	Source dataset link (if available)	License (if available)
PS06 (ANT-III/3)	1984/85	Weddell Sea	J. Gutt	Gutt[21], Gutt[22]	www.pangaea.de/?q=ps06+benthos&f.author%5B%5D=Gutt%2C+Julian&f.pubyear%5B%5D=1985	CC-BY-3.0
PS14 (ANT-VII/4)	1989	Weddell Sea	J. Gutt	Gutt[23], Gutt[24], Gutt[25], Gutt[26],Gutt[27], Gutt[28], Gutt[29], Gutt[30],Gutt[31], Gutt[32], Gutt[33], Gutt[34],Gutt[35], Gutt[36], Gutt[37], Gutt[38],Gutt[39], Gutt[40]	www.pangaea.de/?q=ps14+benthos&f.author%5B%5D=Gutt%2C+Julian&f.pubyear%5B%5D=2010&f.pubyear%5B%5D=1989	CC-BY-3.0
PS18 (ANT-IX/3)	1990/91	Lazarev Sea	J. Gutt	Gutt[41], Gutt[42], Gutt[43], Gutt[44],Gutt[45], Gutt[46], Gutt[47], Gutt[48],Gutt[49], Gutt[50], Gutt[51], Gutt[52],Gutt[53], Gutt[54], Gutt[55], Gutt[56],Gutt[57], Gutt[58], Gutt[59], Gutt[60],Gutt[61], Gutt[62]	www.pangaea.de/?q=ps18+benthos&f.author%5B%5D=Gutt%2C+Julian	CC-BY-3.0
PS61 (ANT-XIX/5)	2002	Antarctic Peninsula	J. Gutt	Arntz and Gutt[63], Arntz and Gutt[64]	https://doi.org/10.1594/PANGAEA.220747 https://doi.org/10.1594/PANGAEA.220746	CC-BY-3.0
PS81 (ANT-XXIX/3)	2013	Antarctic Peninsula	D. Piepenburg	Piepenburg, *et al.*[65]	https://doi.org/10.1594/PANGAEA.872719	CC-BY-3.0
PS96 (ANT-XXXI/2)	2015/16	Weddell Sea	D. Piepenburg	Piepenburg[66]	https://doi.org/10.1594/PANGAEA.862097	CC-BY-3.0
PS118	2019	Antarctic Peninsula	A. Purser	Purser, *et al.*[67]	https://doi.org/10.1594/PANGAEA.911904	CC-BY-4.0
TAN0802	2008	Ross Sea	D. Bowden		https://atlas.niwa.co.nz/	CC-BY-3.0
TAN1802	2018	Ross Sea	D. Bowden		https://atlas.niwa.co.nz/	CC-BY-3.0
TAN1901	2019	Ross Sea	D. Bowden		https://atlas.niwa.co.nz/	CC-BY-3.0
NBP0808	2008	Antarctic Peninsula	C. Smith A. Ziegler	Grange and Smith[68]		
LMG0902	2009	Antarctic Peninsula	C. Smith A. Ziegler	Grange and Smith[68]		
NBP1001	2010	Antarctic Peninsula	C. Smith A. Ziegler	Grange and Smith[68]		
NBP1402	2014	East Antarctica	A. Post	Leventer, *et al.*[69], Post, *et al.*[70]	https://www.usap-dc.org/view/dataset/601310	CC BY-NC 4.0
AA2011	2011	East Antarctica	J. Smith	Smith[71]	data.aad.gov.au/metadata/records/VMS_Benthic_Photography	CC-BY-4.0
NBP1502	2015	Ross Sea	P. Bart	Bart[72]	https://doi.org/10.15784/601182	CC BY-NC 4.0
LMG1311	2013	Antarctic Peninsula	A. Leventer	Domack[73]	https://doi.org/10.15784/601311	CC BY-NC 4.0
JR262	2011	South Orkney	D. Barnes	Barnes and Sands[74], Barnes, *et al.*[75]		
JR15005	2015	South Orkney	H. Griffiths	Brasier, *et al.*[76]		
JR17001	2017	Antarctic Peninsula	D. Barnes	Barnes, *et al.*[77], Zwerschke, *et al.*[78]		
JR17003	2018	Antarctic Peninsula	K. Linse	Linse, *et al.*[79]	https://doi.org/10.5285/48dcef16-6719-45e5-a335-3a97f099e451	http://www.nationalarchives.gov.uk/doc/open-government-licence/version/3/

Table 1. Research campaign (survey) details, including links and references to source data repositories where available (all images available on https://data.imas.utas.edu.au/imagery/IMAS_Antarctic/).

end-coordinates of the transects did not match with expected values given the duration of the deployment and the normal ship-speed during deployment (max 1 kn), we randomly selected 5 of the first 25 images in those transects and assigned these images to the starting position of the transect (Table 2).

The primary image subset we created contains approximately 1 image for every 100 m of transect (3,599 images, Table 3). Further, we created a smaller secondary subset of images for a more detailed exhaustive search of each image, containing approximately 1 image for every 200 m of transect (1912 images, Table 3).

Image annotation. We used both a point-grid and an exhaustive search for annotating the images using the web-based annotation toolkits CoralNet (coralnet.ucsd.edu/) and Biigle BIIGLE 2.0 (www.biigle.de/). Point-grid annotation allows estimating percentage cover of all substrates and organisms present in the image, but the number of points that make up the grid influence how well these percentages are estimated, and how well rare and/or small organisms are detected[14]. In contrast, labelling organisms individually in an exhaustive search reduces detectability issues for rare species. However, individual labels present a challenge for many colonial organisms because individual colony sizes can vary greatly and it is frequently ambiguous how many colonies there are. We chose to first label all images in the primary subset using a point-grid, and then label the secondary subset using an exhaustive search. In the exhaustive search we focussed only on two groups of organisms: Mobile species, and

Survey ID	Metadata quality	Transects included	Comments
PS06	*	2/10	Excluded transect 288: located near/under iceshelf (no available environmental data) Excluded transects 301-303, 307, 309-311: Blurry images
PS14	**	18/24	Image quality low Excluded transects 248, 250, 259, 261: Blurry/discoloured images Excluded transect 274: Coordinates unreliable (transect on land) Excluded transect 312: Located in the South Atlantic
PS18	**	22/25	Excluded transects 162-1, 173-2 & 207-1: located near/under iceshelf (no available environmental data)
PS61	**	2/8	Only included transects 235-1 & 249-1: all other transects are on the Scotia Arc which is not part of this database
PS81	***	29/30	Excluded transect 159: Bad visibility making it difficult to identify organisms
PS96	***	13/13	—
PS118	***	10/11	Excluded transect 38: Bad visibility making it difficult to identify organisms Transects 39 & 69: Reduced transect starts and ends to form straight transect lines
TAN0802	***	17/53	Excluded transects 181-310 which are located on seamounts off the Antarctic continental shelf.
TAN1802	***	31/31	Transects 160-213 are located on seamounts off the Antarctic continental shelf.
TAN1901	***	34/34	Transect 209 is located on a seamount off the Antarctic continental shelf.
NBP0808	**	5/6	Excluded transect 1103: Bad illumination/image quality
LMG0902	**	6/6	—
NBP1001	**	21/22	Excluded transect 1325: Uncertain reliability of coordinates (transect very long with few images only)
NBP1402	**	10/10	—
AA2011	***	71/86	Excluded transects CTD53, CTD55, CTD57-58, CTD61-64, CTD85, CTD90, CTD93, CTD98, CTD107, CTD115 & CTD138: no or only blurry/unusable images
NBP1502	**	5/7	Excluded transects KC16 & KC17: no metadata available/accessible
LMG1311	**	2/2	—
JR262	*	4/23	Image quality very low 4 transects on the South Orkney shelf included, all other transects are off the Antarctic continental shelf/slope
JR15005	**	21/21	—
JR17001	***	7/7	—
JR17003	***	12/12	—

Table 2. Data characteristics for each research campaign (survey) and comments on which data were excluded from annotation efforts. Metadata quality: * single longitude/latitude position for each transect; ** longitude/latitude available for start/end locations of each transect Locations of individual images interpolated from start/end locations; *** longitude/latitude available for each image.

small or rare species comprising Vulnerable Marine Ecosystem taxa (VME taxa as defined by the Commission for the Conservation of Antarctic Marine Living Resources, CCAMLR[15]) that are not colonial.

For point-grid annotation we overlaid all images in the primary subset with a regular grid of 108 points (9×12) to closely match the 3×4 height to width ratio of the images. We chose 108 points as a good compromise between sampling effort and time constraints. For each point we only identified what substrate (e.g. fine substrates, Fig. 3) or organisms (such as different types of suspension feeders, Fig. 4) could be found within the single pixel in the centre of this point. While this required us to regularly zoom in and out of the image to determine the exact position of the point, it reduced potential bias towards labelling a point as an organism instead of substrate. We used CoralNet[16] to manually annotate all images and used the inbuilt deep-learning algorithm, which automatically suggests the five most likely annotation labels for each point, to more quickly select the correct label.

For individually labelling organisms in the secondary subset via an exhaustive search, we used the online toolkit BIIGLE 2.0 and their "lawnmower mode" to systematically search through an image[17]. We identified each organism from the respective morphospecies list and drew a close-fitting circle around the organism if they were mainly (>50% of their body) within the image.

For all images in the primary subset, we used BIIGLE to annotate visible laser-points that allow calculating the imaged seabed area.

After completing annotations and quality control (detailed further below), we uploaded all images and annotations onto Squidle+ for making the data publicly available.

Image classification scheme. We classified all organisms based on CATAMI[9] (Collaborative and Annotation Tools for Analysis of Marine Imagery), and added labels to the classification tree when we could confidently distinguish organisms further into separate morphospecies. CATAMI is a hierarchical

	Number of images				
Survey ID	**Total**	**Included**	**Subset 1**	**Subset 2**	**Image subsetting**
PS06	500	16	9	5	Transect 289: selected 5 random images Transect 292: selected all good quality images (4)
PS14	1523	1098	119	65	Spatially-balanced-random However: Start/end coordinates not trustworthy (ship speed would be > 1 kt) for transects 245, 250, 256, 259, 260, 261, 275, 278-3, 280 & 293: Selected 5 random images out of the first 25 images from these transects, using starting GPS coordinates as image position.
PS18	1705	1456	103	59	Spatially-balanced-random However: Start/end coordinates not trustworthy (ship speed would be > 1 kt) for transects 171-1, 173-1, 206-2, 211-2 & 222-1: Selected 5 random images out of the first 25 images from these transects, using starting GPS coordinates as image position.
PS61	139	129	12	7	Spatially-balanced-random
PS81	14543	14510	1041	528	Spatially-balanced-random
PS96	2736	2727	217	112	Spatially-balanced-random
PS118	12629	6056	260	133	Spatially-balanced-random Transect 11-2: GPS-coordinates wiggle a lot between images - > subset based on distance from start rather than distance along transect Transect 39-1: removed the first 800 and the last 487 images to result in a straight lined transect Transect 69-1: removed the first 29 and the last 50 images to result in a straight lined transect
TAN0802	13046	10887	173	91	Spatially-balanced-random
TAN1802	7470	5566	336	175	Spatially-balanced-random
TAN1901	8301	5952	373	195	Spatially-balanced-random
NBP0808	300	242 (41)	41	22	Spatially-balanced-random
LMG0902	288	260 (82)	82	43	Spatially-balanced-random
NBP1001	1808	1480 (207)	197	104	Spatially-balanced-random
NBP1402	761	453	78	43	Spatially-balanced-random
AA2011	1853	435	71	71	Selected 1 random image per transect due to low number of usable images
NBP1502	2869	1719	245	124	Spatially-balanced-random
LMG1311	263	222	60	31	Spatially-balanced-random
JR262	61	31	17	10	Selected 5 random images per transect
JR15005	773	505	88	53	Spatially-balanced-random
JR17001	142	120	14	8	Spatially-balanced-random
JR17003	850	279	63	33	Spatially-balanced-random
TOTAL	72560	54143 (52491)	3599	1912	

Table 3. Overview of the number of images per research campaign (survey) and how subsets were created. "Total" is the number of images downloaded from the repository; "Included" is the number of images that show the seafloor, are in focus and are neither blurry nor too bright/dark, and are included in our database. "Subset 1" and "Subset 2" are the number of images that were selected for annotation for the point-scoring method and the exhaustive search respectively. Note that only annotated images are publicly available for research campaigns NBP0808 (41 images), LMG0902 (82 images) and NBP1001 (207 images).

classification scheme that uses taxonomy at the higher levels of the classification tree and morphology at the lower levels of the classification tree. This approach accounts for the fact that it is often difficult to identify seafloor fauna to a fine taxonomic resolution without physical specimens and that the morphology of seafloor fauna is often reflective of function. Where further discrimination is known or needed these can be added at the end of the respective CATAMI branch. We then integrated our label tree with the Australian Morphospecies Catalog (AMC) on Squidle+, meaning all labels we used can be found in AMC. For the scoring of VMEs, we combined CATAMI with the VME classification guide provided by CCAMLR[15], and these labels are also integrated into the AMC on Squidle+. A list of the 20 most commonly used labels for each of the three datasets can be found in Tables 5–7.

Quality control & expert review. All annotations went through rigorous quality control comprising three stages: Labelling review, internal QA/QC, and expert review.

Labelling review concerns the exhaustive search only: After all images of a research campaign had been fully annotated in BIIGLE, a second scorer systematically searched through all images again to label any organisms the first scorer had missed. The use of two scorers to search though each image gave us high confidence that few individuals have been missed.

Internal QA/QC: We conducted a two-stage internal QA/QC both individually for each research campaign during annotation and also for all research campaigns combined. In the internal QA/QC we reviewed each

		Depth-range (IBCSO V2)			Size					Annotations	
		for images			of imaged	Laser-	Image		Colour-	Point-grid	Exhaustive search
Survey ID	**Camera-platform**	**included**	**annotated**	**Distance from seafloor**	**seabed area**	**points**	**crop**	**corrected**	**all species & substrate**	**mobile species**	**VME species**
PS06	Photo sledge (FTS)	349–1115	same	Constant (weight)	Unknown	—	No	Yes	972	241	30
PS14	Photo sledge (FTS)	148–1347	same	Constant (weight)	0.56 m^2	—	No	Yes	12852	1110	471
PS18	Photo sledge (FTS)	144–956	176–956	Constant (weight)	1 m^2	—	No	Yes	11124	1889	589
PS61	Photo sledge (FTS)	330–348	same	Constant (weight)	~1 m^2	—	No	Yes	1296	218	13
PS81	OFOS	52–783	same	Variable	Calculated	50 cm	80%	Yes	112428	83888	16756
PS96	OFOS	198–731	same	Variable	Provided + calculated	50 cm	80%	No	23436	7602	4548
PS118	OFOBS	82–2169	same	Variable	Calculated	50 cm	80%	Yes	28080	24900	17272
TAN0802	DTIS	287–2258	same	Variable	Calculated	20 cm	No	Yes	18684	6237	911
TAN1802	DTIS	664–1213	same	Variable	Calculated	20 cm	No	Yes	36288	12279	6689
TAN1901	DTIS	447–1373	same	Variable	Calculated	20 cm	No	Yes	40284	16837	10894
NBP0808	YOYO	573–642	same	Constant (weight, 2.5 m)	~3 m^2 + calculated	10 cm	No	Yes	4428	272	24
LMG0902	YOYO	578–678	same	Constant (weight, 2.5 m)	~3 m^2 + calculated	10 cm	No	Yes	8856	318	36
NBP1001	YOYO	436–725	same	Constant (weight, 2.5 m)	~3 m^2 + calculated	10 cm	No	Yes	21276	5260	650
NBP1402	YOYO	281–899	same	Constant (weight, 2.5 m)	~4.8 m^2 + calculated	10 cm	90%	Yes	8424	2474	351
AA2011	CTD	198–1453	same	Variable	Calculated	50 cm	90%	Yes	7668	5322	569
NBP1502	YOYO	175–597	same	Constant (weight, 2.5 m)	Calculated	10 cm	No	Yes	26460	6242	1802
LMG1311	YOYO	349–654	same	Constant (weight, 2.5 m)	Calculated	10 cm	No	Yes	6480	1720	309
JR262	SUCS	219–280	same	Constant (frame)	0.51 m^2	—	No	Yes	1836	112	29
JR15005	SUCS	473–1017	same	Constant (frame)	0.51 m^2	—	No	Yes	9504	875	666
JR17001	SUCS	67–507	same	Constant (frame)	0.51 m^2	—	No	Yes	1512	74	48
JR17003	SUCS	184–865	same	Constant (frame)	0.51 m^2	—	No	Yes	6804	2702	331
TOTAL		67–2258							388692	180572	62988

Table 4. Details on image collection, image characteristics and annotation.

label, corrected any misclassification and discussed with the team if necessary. For reviewing labels from the grid annotation, we cropped 50 × 50 pixel thumbnails around each grid-point and sorted the thumbnails by their label in a morphospecies library. For reviewing the individual annotations from the exhaustive search using BIIGLE we used BIIGLE's inbuilt "Largo" review function. After this first review, we then created a second library containing only thumbnails of morphospecies whose labels had changed during the review. This second review stage was to ensure all changes made to the original scoring were correct.

Expert review: In the third stage of our review process, co-authors contributed as needed with their taxonomic expertise to ensure the morphospecies grouping and labelling was consistent, and to help identify some of the unknown organisms encountered.

Data Records

All seafloor images, a static version of the annotations and the associated metadata are deposited at the IMAS data portal[18,19] and can be accessed under the following: https://doi.org/10.25959/2R0E-PB18 and https://doi.org/10.25959/SXGA-V355. The image record contains the campaign names for each scientific survey, and within each of these folders are the individual deployments containing the images as well as metadata files ("navdata.csv") with the following key variables:

"key" = Image name
"pose.lon" = Longitude
"pose.lat" = Latitude
"pose.depth" = Depth at the seafloor in m
"pose.alt" = distance of the camera to the seafloor in m
"timestamp.start" = time in UTC
"data.transect_ID" = deployment identifier
"data.image.area" = imaged seabed area in m^2 if available
"data.image_area_source" = how estimates of imaged seabed area were obtained
"data.license" = image license

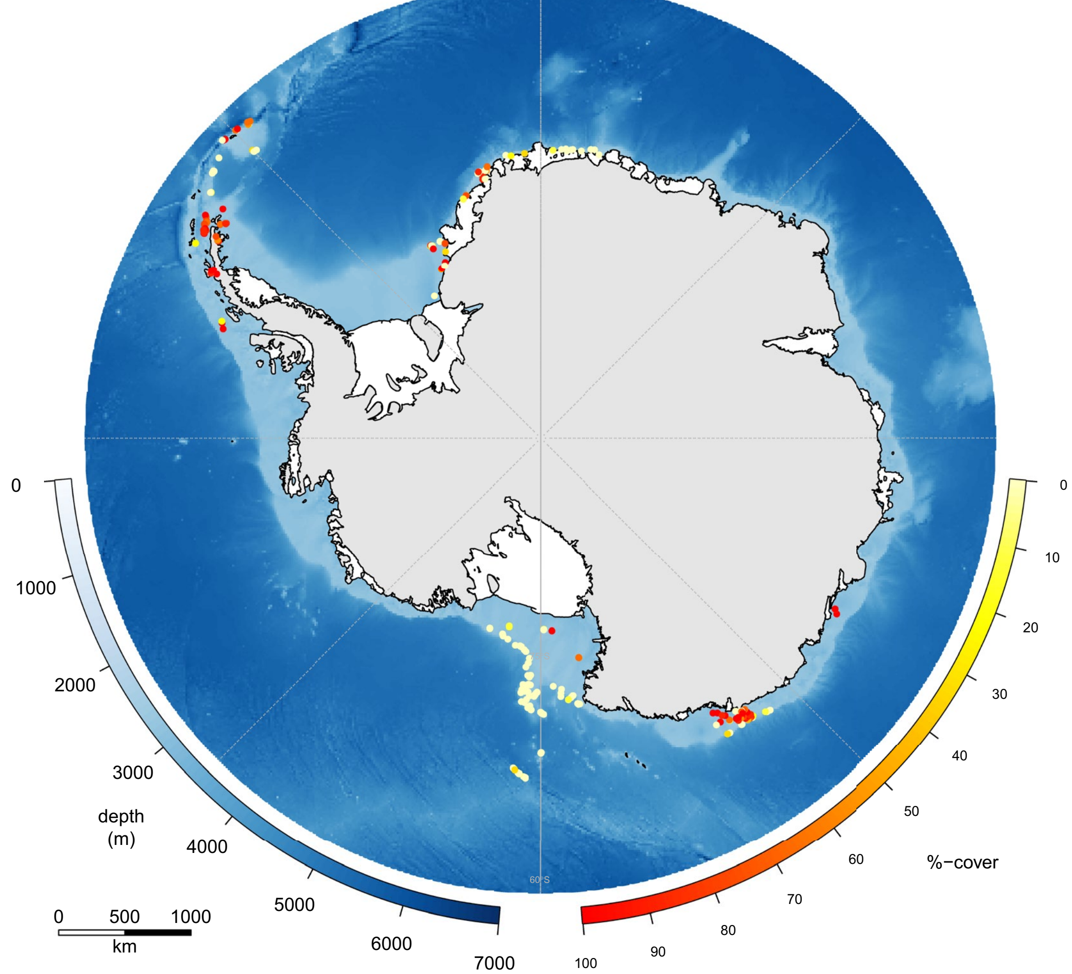

Fig. 3 Example output from AS-AID: Percentage of grid-points identified as fine substrate (mud or sand) in the images from each sampling location.

"data.source_link" = DOI link to original data source where available
"data.equipment" = camera system used to obtain the imagery

The static version of the annotations at the time of publication[18] contains three csv files (Points, Mobiles and VMEs) for each of the 21 research campaigns. The csv files contain all data variables available to download from Squidle+, the most important ones are described in more detail below:

"point.media.key" = image name
"point.media.path_best_thm" = persistent file path to image
"point.y" = annotation point location along the y-axis
"point.x" = annotation point location along the x-axis
"point.bbx" = bounding box coordinates containing the annotated fauna
"point.pose.lon" = Longitude of the image
"point.pose.lat" = Latitude of the image
"label.lineage_names" = full AMC annotation label

Classification catalogues with example annotations for each label used in AS-AID are publicly available[20] and can be access under the following: https://doi.org/10.25959/J4EE-9A56.

All images, annotations and the classification scheme can also be accessed on Squidle+ by filtering for "IMAS Collated Antarctic Imagery".

Technical Validation

Annotations in AS-AID have gone through a rigorous review process involving experienced scientists, trained students and taxonomists. During the annotation process, the annotation team (consisting of two scientists, one postgraduate student and one undergraduate student) met regularly (daily at the beginning, weekly at a later stage and every time a research campaign was fully annotated) to discuss uncertain annotations, ensure consistent annotation between the scorers and create new labels where necessary. All annotations were checked

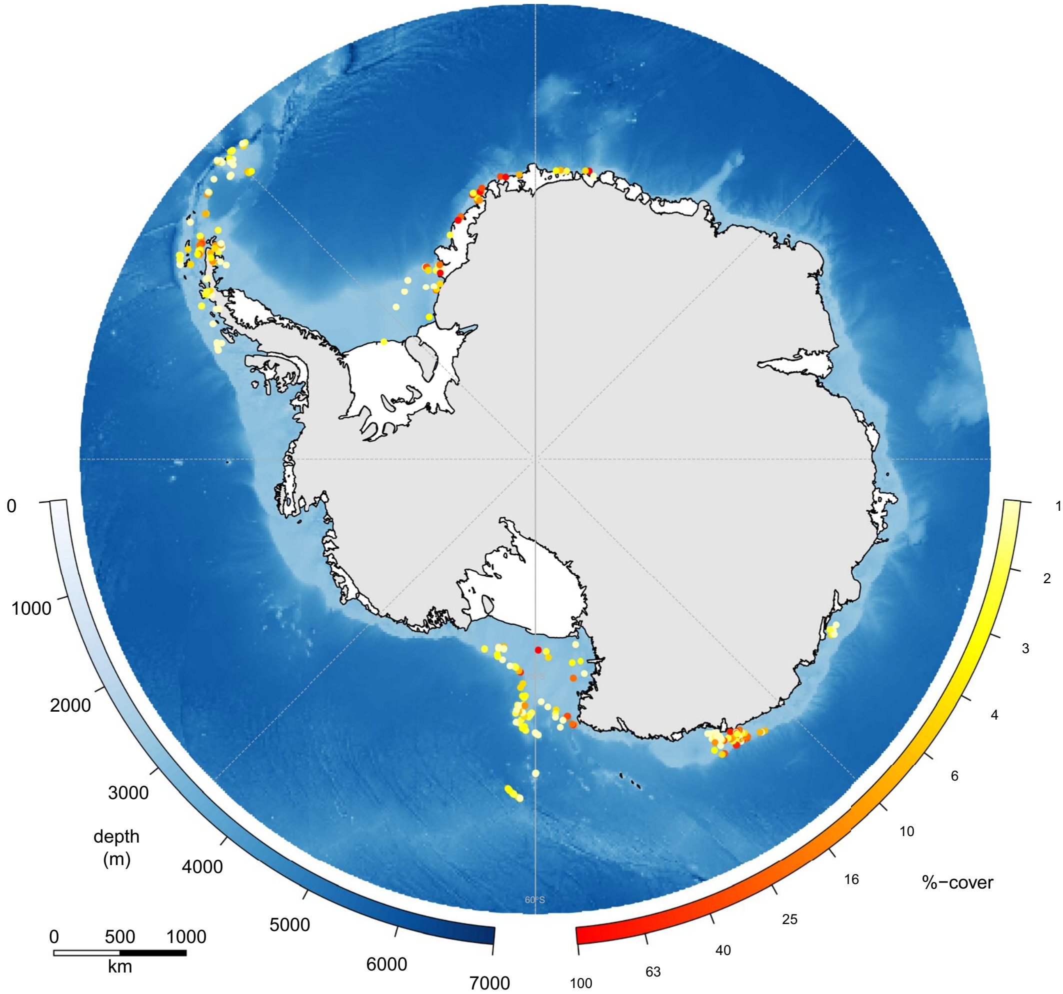

Fig. 4 Example output from AS-AID: Percentage cover of grid-points identified as suspension feeders (combining ascidians, bryozoans, cnidarians, sponges) in images from each sampling location.

for correct labelling once a research campaign was fully annotated and the entire database was checked again after all research campaigns had been fully annotated. Further, expert taxonomists were consulted in particular for key taxa such as sponges, cnidarians and bryozoans. The largest uncertainties in this database were distinguishing whether an object was an organism or substrate, and whether an organism was dead or alive, and we created a number of categories to label these cases accordingly, such as e.g., "Unknown Biological Matrix" or "Unidentifiable".

In AS-AID, we have opted to use experts to consecutively perform tasks on the same set of images. In particular, this meant one expert labelled the images while a second expert checked the annotations in the review process and flagged any misclassifications for discussion. While this process didn't allow label accuracy to be quantified, it did allow organisms to be labelled more consistently throughout the entire database.

Researchers are invited to assess the validity of AS-AID for their own research purposes. Every annotation in AS-AID is linked to an image with a unique filename and contains the x- and y- coordinates where the organisms is located on that image as well as other metadata such as imaged area and imaging gear. Therefore, every annotation is fully traceable, allowing researchers to customise and assess the validity of AS-AID for their needs.

Data availability

All images, annotations and the classification scheme can be openly accessed online via the following links: Images[18]: https://doi.org/10.25959/SXGA-V355 Annotations[19]: https://doi.org/10.25959/2R0E-PB18. Classification catalogs[20]: https://doi.org/10.25959/J4EE-9A56. All data can also be accessed on Squidle+ by filtering for "IMAS Collated Antarctic Imagery".

Label name	Frequency
2 Physical > Substrate > Unconsolidated (soft) > Sand / mud (< 2 mm)	210484
2 Physical > Substrate > Unconsolidated (soft) > Pebble / gravel	82071
2 Physical > Substrate > Unconsolidated (soft) > Pebble / gravel > Biologenic	19912
Unscorable	14629
1.1 Biota > Matrix > Turf/Sediment/Silt matrix	12352
1.1 Biota > Matrix > Bryozoa / Cnidaria Matrix	8920
2 Physical > Substrate > Consolidated (hard) > Cobbles	5072
2 Physical > Substrate > Consolidated (hard) > Rock	4460
1.1 Biota > Bryozoa > Hard > Branching > Antler	3481
2 Physical > Substrate > Consolidated (hard) > Boulders	2334
1.1 Biota > Matrix	1796
1.1 Biota > Echinoderms > Ophiuroids > Brittle / snake stars	1660
1.1 Biota > Bryozoa > Soft > Dendroid	1612
1.1 Biota > Bryozoa > Hard > Fenestrate > Bryozoa Lace	1507
1.1 Biota > Cnidaria > Hydrocorals > Branching	1287
1.1 Biota > Bryozoa > Hard > Branching > Leafy	1247
1.1 Biota > General Unknown Biology	1241
1.1 Biota > Echinoderms > Feather stars > Unstalked crinoids	1013
1.1 Biota > Ascidians > Unstalked > Colonial	825
1.1 Biota > Sponges > Massive forms > Simple	823

Table 5. The top 20 most common labels in the point-scoring analysis. More information on the frequency of each annotation label (including for less commonly used labels) can be found on squidle.org.

Label names (all within Australian Morphospecies Catalog category "Biota")	Frequency
Echinoderms > Ophiuroids > Brittle / snake stars	78798
Worms	46017
Echinoderms > Ophiuroids > Brittle / snake stars > Suspension feeders > Five arms	7667
Crustacea > Prawns / shrimps / mysids	6574
Sea spiders	5278
Crustacea > Amphipoda	2698
Worms > Polychaetes > Tube worms	2601
Echinoderms > Sea cucumbers > Benthic	2450
General Unknown Biology	2427
Echinoderms > Ophiuroids > Brittle / snake stars > Suspension feeders > Six arms > Red Six arm Suspension feeder	2403
Echinoderms > Ophiuroids > Brittle / snake stars > Suspension feeders > Five arms > White Five arm Suspension feeder	2195
Brachiopods	1982
Echinoderms > Feather stars > Unstalked crinoids	1841
Echinoderms > Ophiuroids > Brittle / snake stars > Suspension feeders	1711
Echinoderms > Ophiuroids > Brittle / snake stars > Curly arms	1648
Echinoderms > Sea stars	1644
Echinoderms > Ophiuroids > Brittle / snake stars > Suspension feeders > Six arms > White Six arm Suspension feeder	1581
Echinoderms > Sea cucumbers > Benthic > Suspension feeder	1432
Echinoderms > Sea cucumbers > Benthic > Suspension feeder > Buried > Red tentacles	1053
Echinoderms > Ophiuroids > Brittle / snake stars > Suspension feeders > Seven arms	843

Table 6. The top 20 most common labels in the exhaustive search for mobile species. More information on the frequency of each annotation label (including for less commonly used labels) can be found on squidle.org.

Label names (all within Australian Morphospecies Catalog category "Biota")	Frequency
Ascidians > Unstalked > Colonial	27185
Cnidaria > Corals > Stony corals > Solitary	8258
Ascidians > Stalked > Colonial	7242
Cnidaria > Hydroids > Solitary	3583
Cnidaria > Corals > Black & Octocorals > Whip > Sea Whip > Gorgonacea	3331
Cnidaria > Colonial anemones > Zoanthids	2399
Cnidaria > Corals > Black & Octocorals > Branching (3D) > Non-fleshy > Bottle-brush > Simple > Gorgonacea	2379
Cnidaria > True anemones	1828
Ascidians > Stalked > Solitary	1607
Ascidians > Unstalked > Solitary	1413
Brachiopods	982
Cnidaria > Corals > Black & Octocorals > Fan (2D) > Fern-frond > Simple	615
Cnidaria > Hydroids > Colonial	436
Cnidaria > Corals > Black & Octocorals > Branching (3D) > Fleshy > Mushroom	364
Cnidaria > Corals > Black & Octocorals > Branching (3D) > Non-fleshy > Arborescent > Gorgonacea	253
Cnidaria > Corals > Black & Octocorals > Branching (3D) > Non-fleshy > Bushy	205
Cnidaria > Corals > Black & Octocorals > Branching (3D) > Non-fleshy > Bottle-brush > Complex > Gorgonacea	177
Cnidaria > Corals > Black & Octocorals > Quill (seapen)	165
Cnidaria > Corals > Black & Octocorals > Whip > Sea Whip > Alcyonacea	121
Molluscs > Bivalves > Scallop > Adamussium colbecki	110

Table 7. The top 20 most common labels in the exhaustive search for selected VME species. More information on the frequency of each annotation label (including for less commonly used labels) can be found on squidle.org.

Code availability

Image annotations and metadata can also be directly accessed using the software packages "SQAPI" for R (available from https://github.com/sajessop/SQAPI) and "sqapi" for python (available using "pip install sqapi").

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Author contributions

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Competing interests

The authors declare no competing financial interests.

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