Statewide Marine Habitat Map

Habitat Complex Mapping Method (CBiCS Level 3)

January 2023

Biodiversity Division | Biodiversity Protection and Information | Marine Knowledge Unit

VICTORIA State Government
Energy, Environment and Climate Action

OFFICIAL

Author

Tessa Mazor: Marine Spatial Analyst, DEECA
Kate Watermeyer: Marine Spatial Analyst, DEECA
Trent Hobley, Senior Data Applications Officer, DEECA
Vincent Grinter, Data Applications Officer, DEECA
Rhiannon Holden, Marine Spatial Analyst, DEECA
Kimberley MacDonald: Marine Biodiversity Manager, DEECA
Lawrance Ferns: Marine Knowledge Manager, DEECA

Citation

Mazor, T., Watermeyer, K., Hobley, T., Grinter, V., Holden, R., MacDonald, K. and Ferns, L. (2023). Statewide Marine Habitat Map. Habitat Complex Modelling Method (CBiCS Level 3). The State of Victoria Department of Energy, Environment and Climate Action.

Acknowledgements

DEECA would like to acknowledge and thank all individuals who provided data to support the outcomes of this work: Dr. Matt Edmunds: Australian Marine Ecology Pty Ltd, Dr. Adrian Flynn: Fathom Pacific Pty Ltd, Dr. Jin Liu: Coastal Processes Science Officer, DEECA, Dr. Mary Young, Postdoctoral Researcher, Deakin University.

Photo credit

Front cover: Dr Matt Edmunds, Australian Marine Ecology

ISBN 978-1-76136-204-10

Acknowledgment

We acknowledge and respect Victorian Traditional Owners as the original custodians of Victoria's land and waters, their unique ability to care for Country and deep spiritual connection to it. We honour Elders past and present whose knowledge and wisdom has ensured the continuation of culture and traditional practices.

We are committed to genuinely partner, and meaningfully engage, with Victoria's Traditional Owners and Aboriginal communities to support the protection of Country, the maintenance of spiritual and cultural practices and their broader aspirations in the 21st century and beyond.

Accessibility

If you would like to receive this publication in an alternative format, please telephone the DEECA Customer Service Centre on 136186, email customer.service@delwp.vic.gov.au or via the National Relay Service on 133 677 www.relayservice.com.au. This document is also available on the internet at www.delwp.vic.gov.au.

Marine Habitat Map

The habitat map represents 24 marine and coastal communities across Victoria’s state waters. Developed from a mosaic of former mapping products, aerial imagery, field observation records, environmental variables and novel machine learning methods that model and predict habitat distributions. The map aims to provide fundamental ecological information for supporting planning, monitoring, and management decisions in the marine environment.

Purpose statement

The purpose of this report is to describe the methods used to develop a broad-scale habitat map across Victoria’s state waters. The report details the input data, modelling methods, accuracy and limitations as well as outlines the broad applications of the map. The state habitat map addresses the Marine & Coastal Strategy 2022, building knowledge to improve the condition and ecological connectivity of habitats, and protecting Victoria’s environment - Biodiversity 2037, improving our knowledge of habitats and their extent to support their protection and restoration.

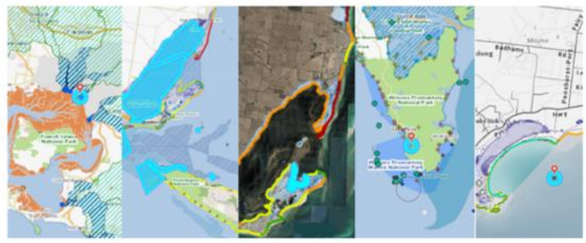
1. Victoria’s marine environment

Victoria’s marine waters supports many different natural habitats. Along the foreshore are sandy beaches, rocky intertidal reefs, mud flats, mangroves, and saltmarshes. Other marine habitats below the surface within include seagrass meadows, rocky reefs, sponge gardens and unvegetated soft sediments. Unvegetated soft sediments on the seafloor are home to a diverse array of invertebrates and micro-organisms that are critical in processing nitrogen and other nutrients (Edmunds et al. 2021).

Victoria’s marine and coastal waters provide habitat for a diversity of marine plants and animals, many of which are endemic (VEAC 2019). Seagrasses provide nurseries for many fish and invertebrate species, including important commercial and recreational fish species such as King George Whiting and Black Bream. Rocky reefs provide hard substrate on which hundreds of species of fish, molluscs, crustaceans, marine worms, jellyfish, sea anemones, algae (seaweeds) can be found (VEAC 2019). Victoria’s marine habitats are home to mammals such as Southern Right whales,

CoastKit

CoastKit is DEECA’s online platform for environmental managers and researchers, that synthesises coastal scientific data and resources.



The spatial toolkit promotes standardised data classification for collection, reporting, monitoring and assessment across Victoria. CoastKit support marine managers by interactive tools that facilitate:

- marine habitat (biotope) maps
- environmental impact assessments
- marine spatial planning
- ecosystem modelling
- coastal hazard assessments
- ecosystem-based management

Ultimately, CoastKit unifies and disseminates relevant information to improve the efficiency and effectiveness of decision making, ensuring the future health and sustainability of Victoria’s unique marine and coastal assets.

https://mapshare.vic.gov.au/coastkit/

Humpback whales, Blue whales, Burrunan dolphins, Common dolphins and the Australian fur seal. The coastal wetland areas, beaches, bays, inlets and estuaries provide critical habitat for seabirds such as gannets and little penguins, and shorebirds (e.g. terns and oystercatchers), with sites recognised on the East Asian-Australasian Flyway Site Network.

State waters

The ‘marine environment’ as defined in Victoria’s *Marine and Coastal Act 2018,* extends from the high-water mark for 3 nautical miles, or 5.5 km, to the edge of the State’s jurisdiction. It includes all bays, inlets, estuaries, and the Gippsland Lakes. This extends to a depth of 200m below the seabed, and includes the biodiversity associated with both land and water.

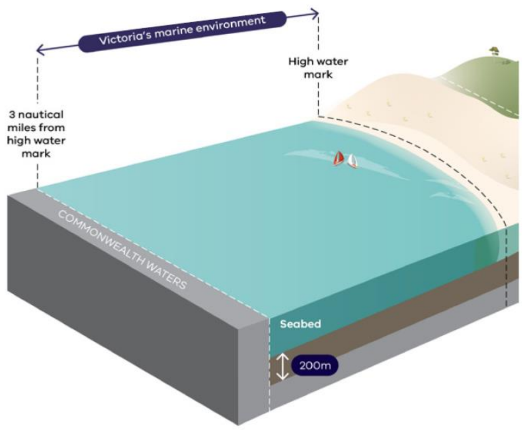


Figure 1. Extent of Victoria’s state waters

Marine habitat classification

The habitat map uses the Combined Biotope Classification Scheme (CBiCS) as developed and described by Edmunds and Flynn (2015, 2018; 2021). CBiCS has six, hierarchical classification components:

- Level 1 – Environment
- Level 2 – Broad Habitat
- Level 3 – Habitat Complex
- Level 4 – Biotope Complex
- Level 5 – Biotope
- Level 6 – Sub-biotope.

The hierarchical design (Figure 2) is adopted directly from the United Kingdom’s Joint Nature Conservation Committee (JNCC) scheme that is a proven system for classification. With some conversion, many of the actual classes from the JNCC scheme that are mapped in Europe (e.g. seaweed biotopes, mussel, worm, and other biogenic reefs) were imported directly into the Australian context (Edmunds et al. 2021). This scheme also aligns with the terrestrial Ecological Vegetation Class (EVC) system for recording mangrove and saltmarsh biotopes.

2. Habitat model

A habitat model was built to predict habitat distributions by applying machine learning tools which integrate ground truthed data and environmental predictors. Level 3 Habitat Complex was selected providing the lowest classification (Figure 2) with data availability to support a broad-scale model across the state.

Previous mapping of statewide marine habitats (DELWP 2021) has been achieved by a compilation of mapping efforts across different regions, reclassified to CBICS level 2 and level 3. Such maps included Port Phillip Bay habitats (Edmunds and Flynn 2018; Mazor et al. 2021), open coast mapping by Deakin Marine Mapping lab (Ierodiaconou 2007, Ierodiaconou et al. 2018, Young et al. 2022), wetland habitats by Boon et al. (2011), GeoHab Victoria Estuaries Geomorphology (2010), Deakin Marine Mapping (Zavalas, R et al. 2018), DELWP wetlands (1994), Monk et al 2011, Roob and Ball (1997), Ford et al 2016, Edmunds and Flynn (2015), Blake and Ball (2001), Poore (1992), Cohen et al (2000). Additional benthic survey data and data on environmental predictors has since been developed with the potential to improve mapping outputs, fill in data gaps and provide a uniform classification output at CBICS level 3. This report describes the steps taken to develop an updated broad-scale habitat map across Victoria’s state waters, as well as a method and baseline for future data to build upon.

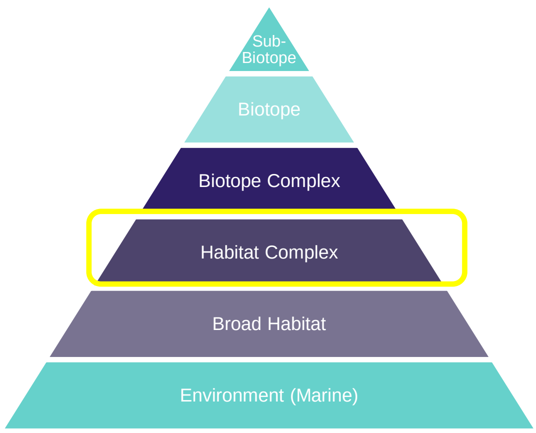


Figure 2. Hierarchical classification system CBiCS components (Edmunds et al. 2021). Level 3 is highlighted in yellow to indicate the level at which the resulting habitat model was constructed.

Figure 3. Ground truth samples (32,998 records at level 3) across Victoria's state waters. Base map source: ESRI, (2021). DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX.

Step 1: Ground-truth records

Ground-truth survey data provide the primary data to build the habitat model. Field observations of Victorian marine species and habitat records are categorised according to the CBiCS method to the lowest hierarchical level where possible. Records are combined from various sources including habitat mapping, monitoring, impact assessments and historical ecological surveys. Across Victoria's state waters 32,998 ground-truth records have currently been categorised to level 3 - Habitat Complex from 1949 to 2019 (Figure 3; Appendix Figure A1, A2 & Table A1). These records can be explored spatially using the 'Biotope Atlas Tool' in CoastKit.

Step 2: Environmental predictors

Variables considered important predictors for marine habitats (such as habitat related fauna and flora) and that have associated gridded data products at a high resolution across Victoria's state waters were included in the model (Table 1). A total of 28 environmental predictor rasters were included in the habitat modelling method. Environmental predictor data was obtained from a variety of different sources as well as calculated using the Benthic Terrain Modeler (BTM; Walbridge et al. 2018) toolbox in ArcGIS Pro (ESRI 2021) and mapped at a resolution of 10 metres (e.g. Figure 4). The resolution was chosen to match the digital elevation model (Victorian Coastal Digital Elevation Model 2021 - VCDEM). Predictor data were largely complete across the study region with few missing values (0-5% of coverage). Missing values were filled by interpolations and resampled to ensure all predictor layers were at the same extent, coordinate system (GDA2020 Vicgrid) and resolution using ArcGIS Pro (ESRI 2021).

Step 3: Machine learning method

Random Forest is an ensemble model using bagging as the ensemble method and decision trees as the individual model (Breiman 2001). Ensemble models incorporate multiple models to make overall predictions, thus incorporating the variance within different models to give results that are less sensitive and that are more robust (less bias and less variance). Random Forest uses a bagging approach where subsets of the data are used to train each model in parallel (not sequential; Figure 5). Random Forest is not affected by correlated variables as per other modelling approaches as it uses a random selection of variables to build trees.

Table 1. Overview of the 28 environmental predictors used in the habitat model. For full details of each predictors see Table A2.

Environmental Predictors	Description
Bathymetry	DEM from lidar and multibeam data at 10 m resolution (VCDEM2021).
Chlorophyll	Chlorophyl a including range, minimum, maximum and mean (IMOS 2000a).
Productivity	Net primary production (NPP) including range, minimum, maximum and mean, (IMOS 2000b).
Temperature	Sea surface temperature (SST) including range, minimum, maximum and mean, (IMOS 2000a).
Sediment	Percentage of gravel, sand and mud (Geoscience Australia; Li et al. 2011a,b,c).
Distance to Coast	Euclidean distance
Waves	Mean wave orbital velocity (Liu et al. 2022).
Currents	Average current speed.
Benthic Terrain	Benthic terrain characteristics were computed using the Benthic Terrain Modeler (Walbridge et al. 2018). ➢ Slope ➢ Curvature ➢ Aspect (north and east) ➢ Benthic position index (BPI; broad, fine and std) ➢ Terrain Ruggedness

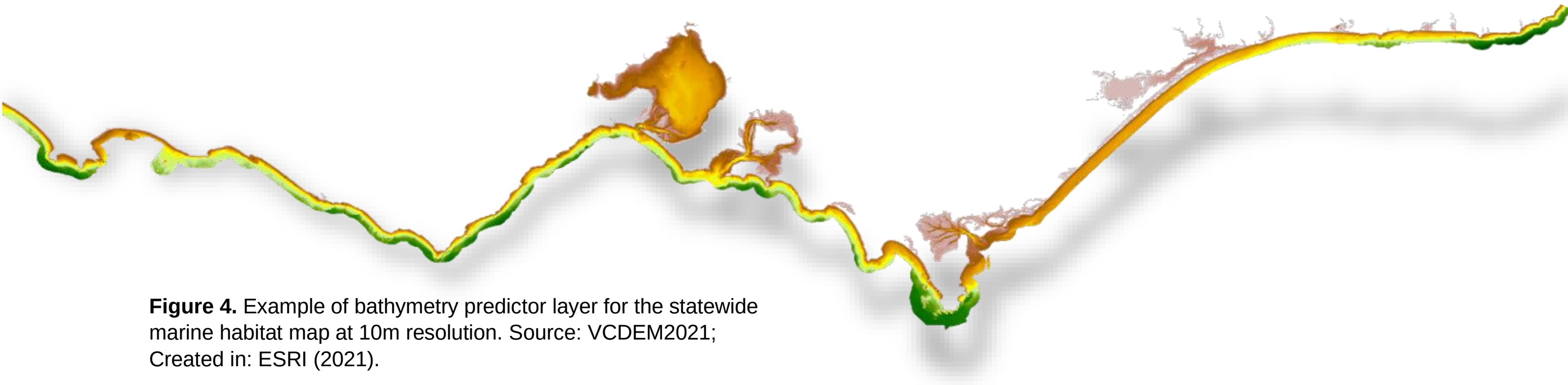


Figure 4. Example of bathymetry predictor layer for the statewide marine habitat map at 10m resolution. Source: VCDEM2021; Created in: ESRI (2021).

Random Forest is considered an effective modelling method for marine habitats and biodiversity with application across the globe and high performance achieved in comparison to other methods (Wei et al. 2010; Pitcher et al. 2012; Peterson & Herkul 2017; McLaren et al. 2019). To map the multiple habitat types for Level 3 Habitat Complex across Victorian waters, the Random Forest classification algorithm was used. Analyses were implemented in the R computing environment (R Core Team, 2021) using package "randomForest" (Liaw & Wiener, 2002). A total of 32,998 ground-truth records were used within the model that met the Random Forest modelling criteria (≥5 unique values for each biotope category; Breiman 2001).

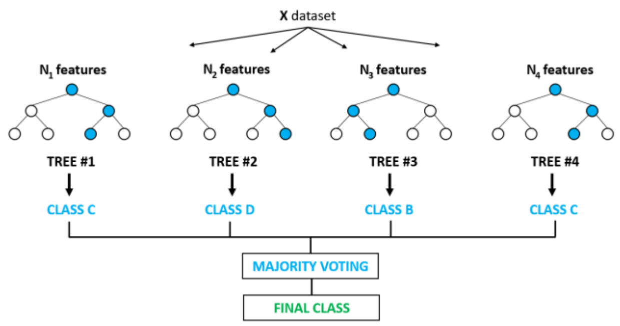


Figure 5. Example of decision trees used in the random forest model. Source: Martinez, E. et al. (2018).

The Random Forest algorithm can be tuned according to parameter settings. A grid search approach was applied based on the out-of-bag (OOB) estimate of error to optimize the random forest parameters. Three parameters which are considered to influence the model were tuned; 1) the number of variables randomly sampled as candidates at each split (*mtry*), 2) the number of trees to grow (*ntree*), and the maximum number of terminal nodes that trees in the forest can have (*maxnodes*). Random Forest has inbuilt cross-validation using bootstrapping. By default, Random Forest picks up two-thirds of the data for training and rest for testing. Trees are also constructed from randomised variable selection and is not prone to overfit unlike other models.

3. Habitat map

The resulting habitat map is presented in Figure 6, representing 24 different habitat complexes at CBiCS level 3. The habitat map was compiled by assessing and synthesising previous mapping products that provided higher resolution mapping (i.e. aerial imagery, field observations, higher resolution predictive mapping) and filling in remaining areas with the predictive habitat model (see Table A3 for full details on combined maps). By area, 83% of the final map is attributed by the predictive model, with the remaining 17% from previous habitat mapping products.

The most dominant habitat types (Figure 7) are sublittoral sand and muddy sand (ba5.2), high energy infralittoral rock (ba3.1). However, a diversity of habitat complexes is present, with prominent habitat of high energy open coast circalittoral rock (ba4.1) found across the western part of the Victorian coastline, and sublittoral mixed sediments (ba5.4), sublittoral rhodolith beds (ba5.5), and sublittoral coarse sediment (ba5.1) patches found across the eastern coast. Sublittoral seagrass beds (ba5.8) are found across the bays and inlets, in particular Port Phillip Bay, Western Port and Corner Inlet.

Port Phillip Bay and Western Port Bay support a wider diversity of habitats. A mosaic of habitats is found across Port Phillip Bay with sublittoral mud (ba5.3) in the centre, sublittoral seaweed on sediment (ba5.7), which supports various seaweed communities as well as drift algae mats, and non-reef sediment epibenthos (ba5.2) characterised by mixed sublittoral sediments covered by epibenthic biota including scallop beds, seapen beds, Pyura and ascidians. Dominant habitats of Western Port Bay include littoral mud (ba2.3), sublittoral sand and muddy sand (ba5.2), and littoral and sublittoral seagrass beds (ba2.7 and ba5.8) with patches of mangroves (ba2.6), non-reef sediment epibenthos (ba5.b), high energy infralittoral rock (ba3.1), moderate energy infralittoral rock (ba3.2) and a mosaics of other habitat patches.

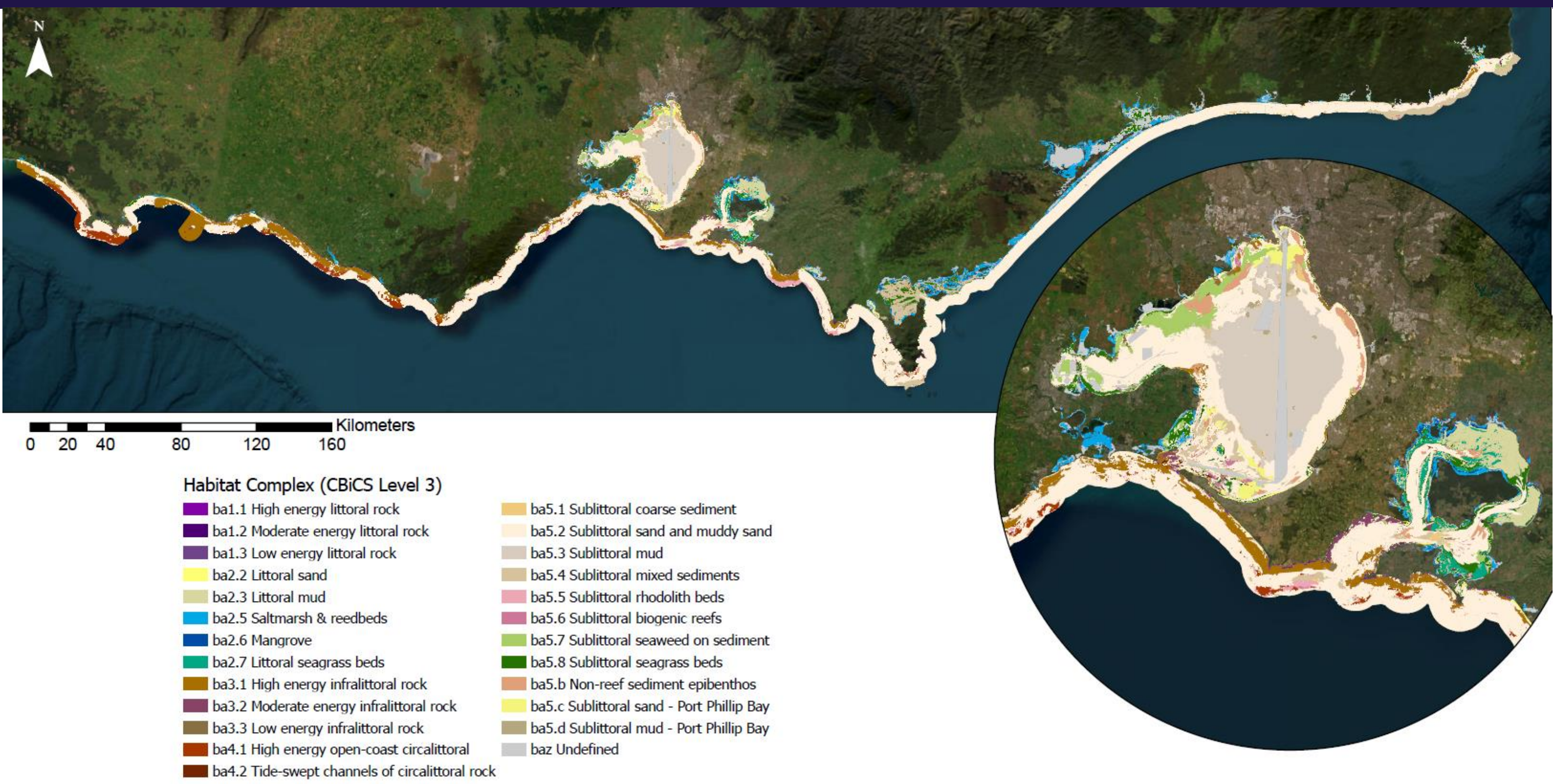


Figure 6. Statewide marine habitat map (Level 3 CBiCS). Created in R (R Core Team, 2021) and mapped in ArcGIS (ESRI 2021). See Figure A3 more details.

Saltmarsh and reedbeds (ba2.5; Boon et al. 2011), and mangroves (ba2.6; Edmunds & Flynn 2018) were not modelled in this study due to their different environmental variables as well as their well described distribution. These habitats were therefore joined to the habitat map after the modelling process.

Random forest modelling produced an accuracy (Out-of-bag) of 89%. Bathymetry, waves, aspect, sea surface temperature and ruggedness, were important predictors in the model (Figure A4, Figure A5). For full a full description of habitat classes and their accuracy see the Table A4. The resulting raster data were processed into polygon data using the ArcGIS Conversion and Cartography tool sets (ESRI 2021). Polygon data were aggregated at 25 metres and do not represent the fine resolution from the raster data (Table A5 for methods). The polygonised data were also assessed against previous mapping products across the bay, satellite and aerial imagery and marine navigation charts, with small edits made for alignment.

Limitations of the model include the reliance upon past ground-truthed data, where habitat changes and shifts may have occurred. Habitat areas depicted in this model may also represent areas which are suitable for particular habitats, however, they may not exist in that exact location. For example, seagrass is largely ephemeral in bays and inlets, which varies where its growth is influenced by environmental conditions. Habitats represented at CBiCS level 3 will also comprise of a mosaic of biotopes and in some cases the represented habitat will not accurately define the integrated habitat complexes. Similarly, the model relies upon environmental variables to find a niche of suitable parameters that characterise the habitat complex across the state waters. Hence, inclusion of other environmental variables may improve the accuracy of the results and importantly environmental variables also contain some degree of uncertainty.

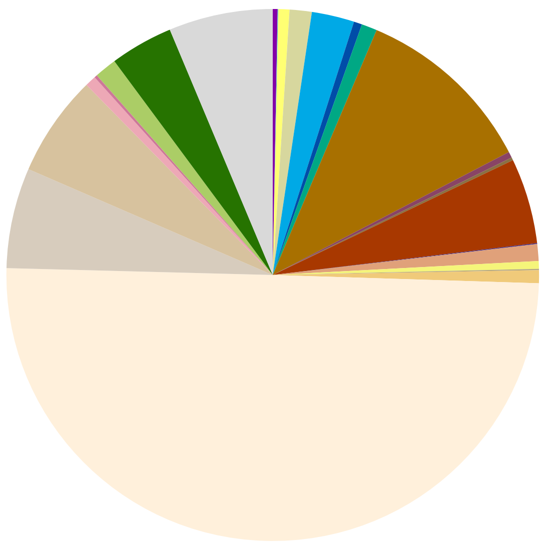


Figure 7. Proportion of habitat complexes across Victoria.

4. Applications

The habitat complex (Level 3 CBiCS) map supports knowledge of the broad scale distributions and extent of marine habitats across Victoria. Importantly, these habitats encompass a range of other species, for example sublittoral seagrass beds (ba5.8) may contains a diversity of seagrass species including genera *Cymodocea, Halophila, Posidonia, Ruppia, Thalassia, Zostera*, which are not depicted individually in the map. Some of these species may be more vulnerable than others, and some may or may not be present within the habitat complex that is mapped.

The map should be used at broad scales of >25 m, and where information of larger habitat complexes is needed. In some situations, for example, when examining the potential impacts of offshore developments, finer resolution mapping may be required with depiction of higher levels of CBiCS classification (i.e. level 4 and 5). However, the habitat complex map can serve as a first indicator of the potential presence of species that may exist within the larger habitat complex, and flag areas where further detailed mapping could be undertaken. The current habitat map presented here provides broad habitat complexes across the state and provides greater knowledge of the ecological diversity across Victoria's waters. This work can support the management of large-scale habitats, their condition, marine spatial planning, strategic management prospect (SMP) and other broad scale applications for supporting effective management decisions across Victoria. The statewide habitat map also supports undertaking risk asssesments using the new Feature Activity Sensitivity Tool, FeAST.

Habitat models can be easily improved as more ground-truth data are obtained. Similarly, the incorporation of more relevant environmental predictor data such as hydrodynamics and satellite imagery can help improve model performance as they become available. Finer resolution models and habitat maps to CBiCS level 4 to 6, can be achieved with the availability of more data. The habitat model (level 3) and resulting map provides an updated broad-scale habitat map across Victoria's state waters and provides a baseline for future data to build upon.

FeAST

The Feature Activity Sensitivity Tool FeAST is a new DEECA toolkit that supports first pass risk assessments in Victoria's marine and coastal areas. FeAST assists proponents of offshore developments in assessing their proposed activities, the associated environmental pressures and the possible risks posed to marine habitats. The statewide habitat map provides a foundation dataset to undertake the

assessment and determine the habitat types and their sensitivities to offshore developments.

The FeAST assessment is hosted on CoastKit, with an interactive application generating a risk assessment report. FeAST is a novel data driven approach to enable fast, efficient and transparent risk assessments that help ensure the health and protection of Victoria's marine and coastal ecosystems.

References

Boon, P.I. et al. (2011). *Mangroves and coastal saltmarsh of Victoria: distribution, condition, threats and management*. Report to DSE, Bendigo. 513 pp.

Breiman, L. (2001). Random forests. *Machine learning*, 45: 5-32.

Cohen, B.F., Currie, D.R. and McArthur, M.A. (2000). Epibenthic community structure in Port Phillip Bay, Victoria, Australia. *Marine and Freshwater Research*, 51: 689-702.

DELWP (2021). Statewide Marine Habitat Map 2021. ANZVI0803009286. Department of Environment, Land, Water & Planning 2022. Available: https://datashare.maps.vic.gov.au/search?q=uuid%3D545463df-853e-5c13-b585-0785c8e5e357

Edmunds, M. and Flynn, A. (2015). *A Victorian Marine Biotope Classification Scheme.* Australian Marine Ecology Report No. 545. Melbourne.

Edmunds, M. and Flynn, A. (2018). *CBiCS Classification of Victorian Biotopes*. Report to Department of Environment, Land, Water and Planning. Australian Marine Ecology Report No. 560, Melbourne. 176 pp.

Edmunds, M., Flynn, A. and Ferns, L. (2021). *Combined Biotope Classification Scheme (CBiCS). A New Marine Ecological Classification Scheme to Meet New Challenges*. The State of Victoria Department of Environment, Land, Water and Planning 2021.

ESRI (2021). ArcGIS Pro 2.8.0 Redlands, CA: Environmental Systems Research Institute.

Ierodiaconou, D., Schimel, A. C. G., Kennedy, D., Monk, J., Gaylard, G., Young, M., Diesing, M. and Rattray, A. (2018b). Combining pixel and object-based image analysis of ultra-high resolution multibeam bathymetry and backscatter for habitat mapping in shallow marine waters. Marine Geophysical Research, 39, 271-288. https://doi.org/10.1007/s11001-017-9338-z

Ierodiaconou, D., Laurenson, L., Burq, S., and Reston, M. (2007). Marine benthic habitat mapping using multibeam data, georeferenced video and image classification techniques in Victoria, Australia. – J. Spat. Sci. 52(1): 93-104.

IMOS (Integrated Marine Observing System). (2022a). IMOS - SRS - MODIS - 01 day - Chlorophyll-a concentration (GSM model). 1 km resolution, Annual composites of Year 2009 - 2019. Retrieved from: https://catalogueimos.aodn.org.au/geonetwork/srv/api/records/f73daf07-eb81-4995-a72aca903834509f

IMOS (Integrated Marine Observing System). (2022b). IMOS - SRS - MODIS - 01 day – Net Primary Productivity (GSM model and Eppley-VGPM algorithm).1 km resolution, Annual composites of Year 2009 – 2019, Retrieved from: https://catalogue-imos.aodn.org.au/geonetwork/srv/api/records/27cc65c0-d453-4ba3-a0d6-55e4449fee8c

IMOS (Integrated Marine Observing System) (2022c). IMOS - SRS - SST - L3S - Single Sensor - 1 day - day time - Australia. Annual composites of Year 2009 – 2019, 2 km resolution. Retrieved from: https://catalogueimos.aodn.org.au/geonetwork/srv/api/records/8bd3fe33-fd98-4307-ad23-424ad9a2907b

Liaw, A., and Wiener, M. (2002). Classification & regression by randomForest. *R News*, 2: 18–22.

Li, J., Heap, A.D.,Potter, A. and Huang, Z. (2011a). Seabed Gravel Content Across the Australian Continental EEZ, 2011. dataset: http://pid.geoscience.gov.au/dataset/ga/71981

Li, J., Heap, A., Potter, A. and Huang, Z. (2011b). Seabed Sand Content Acros the Australian Continental EEZ, 2011. dataset. http://pid.geoscience.gov.au/dataset/ga/71982

Li, J., Heap, A.D., Potter, A., Huang, Z. and Daniell, J.J. (2011c). Seabed Mud Content Across the Australian Continental EEZ, 2011. dataset. http://pid.geoscience.gov.au/dataset/ga/71977

Liu, J., Meucci, A., Liu, Q., Babanin, A. V., Ierodiaconou, D., and Young, I. R. (2022). The wave climate of Bass Strait and south-east Australia. Ocean Modelling, 172, 101980. https://doi.org/10.1016/j.ocemod.2022.101980.

Martinez, E. et al. (2018). Evading deep neural network and random forest classifiers by generating adversarial samples. *International Symposium on Foundations and Practice of Security*, 143-155.

Mazor, T., Edmunds, M., Flynn, A., Ferns, L. DELWP (2021). Port Phillip Bay Habitat Map. Habitat Complex Modelling (CBiCS Level 3). The State of Victoria Department of Environment, Land, Water and Planning 2021.

McLaren, K., McIntyre, K. and Prospere, K. (2019). Using the random forest algorithm to integrate hydroacoustic data with satellite images to improve the mapping of shallow nearshore benthic features in a marine protected area in Jamaica. *GIScience & Remote Sensing*, 56: 1065-1092.

Peterson, A. and Herkül, K. (2019). Mapping benthic biodiversity using georeferenced environmental data and predictive modeling. *Marine Biodiversity*, 49: 131-146.

Pitcher, C.R, Lawton, P., Ellis, N., Smith, S.J., Incze, L.S., Wei, C.L., Greenlaw, M.E., Wolff, N.H., Sameoto, J.A. and Snelgrove, P.V. (2012). Exploring the role of environmental variables in shaping patterns of seabed biodiversity composition in regional-scale ecosystems. *Journal of Applied Ecology*, 49: 670-679.

Poore, G.C. (1992). *Soft-bottom macrobenthos of Port Phillip Bay: a literature review*. Technical Report No. 2, CSIRO.

R Core Team (2021). R: A language and environment for statistical computing. R Foundation for Statistical Computing. http://www.R-project.org/

Victorian Environmental Assessment Council (VEAC) (2019). Assessment of the Values of Victoria's Marine Environment –

Report. Victorian Environmental Assessment Council, Melbourne. Retrieved from: https://apo.org.au/sites/default/files/resource-files/2019-05/apo-nid243676_5.pdf

Walbridge, S., Slocum, N., Pobuda, M. and Wright, D.J. (2018). Unified Geomorphological Analysis Workflows with Benthic Terrain Modeler.Geosciences 8: 94. doi:10.3390/geosciences8030094

Wei, C.L., Rowe, G.T., Escobar-Briones, E., Boetius, A., Soltwedel, T., Caley, M.J., Soliman, Y., Huettmann, F., Qu, F., Yu, Z. and Pitcher, C.R. (2010). Global patterns and predictions of seafloor biomass using random forests. *PloS one*, 5: p.e15323.

Young, MA, Porskamp, P, Critchell, K, Treml, E, Ierodiaconou, D, Pocklington, JB, Sams, MA (2022) Statewide assessment of Victorian marine protected areas using existing data. Parks Victoria Technical Series 118, Parks Victoria, Melbourne.

Appendix

Figure A1. Number of ground-truth records (CBiCS Level 3 - Habitat Complex) sampled across Victoria's state waters per year from 1949 to 2019. Note that some records may have been excluded in the model output due to modelling criteria.

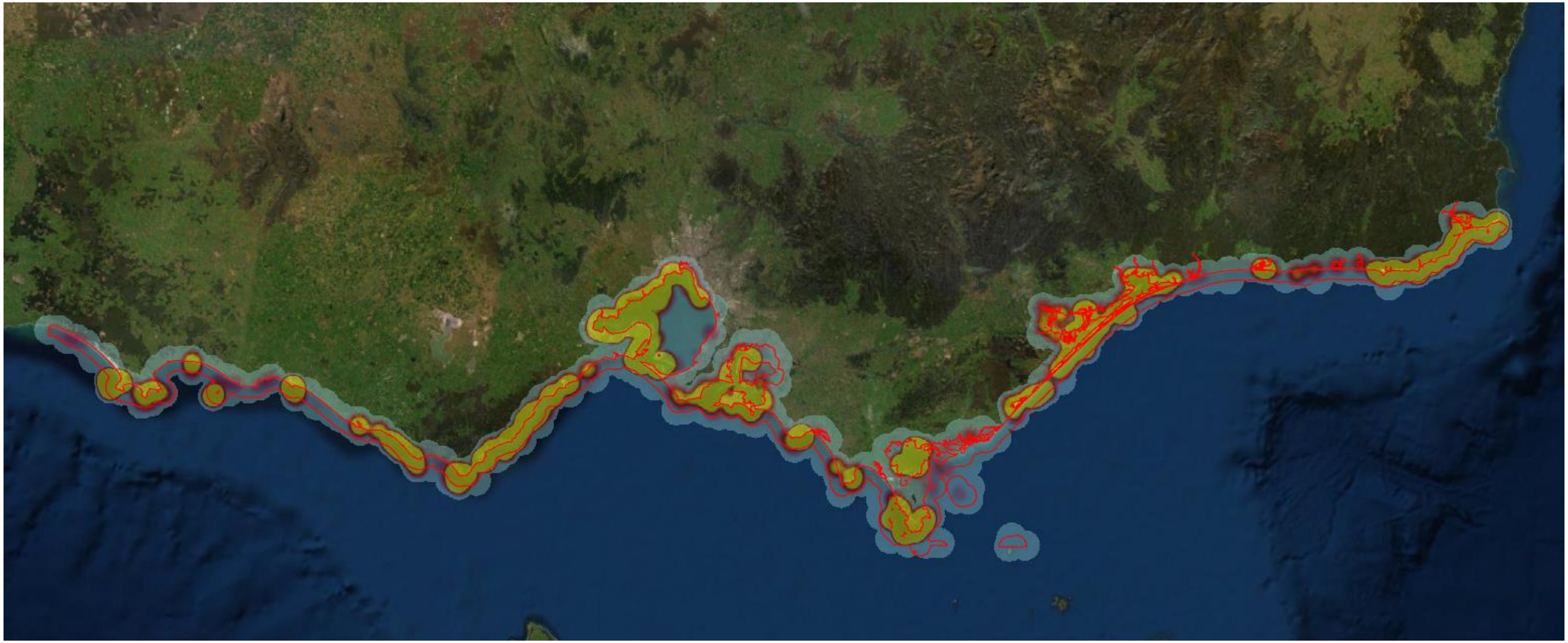


Figure A2. Heat map of biotope records (CBiCS Level 3 - Habitat Complex). Biotopes represented on CoastKit's Biotope atlas at higher CBiCS levels (e.g. Level 4 – 6), have been represented at level 3 for the purpose of gaining the most possible ground truthed data. State marine boarders are delineated in red.

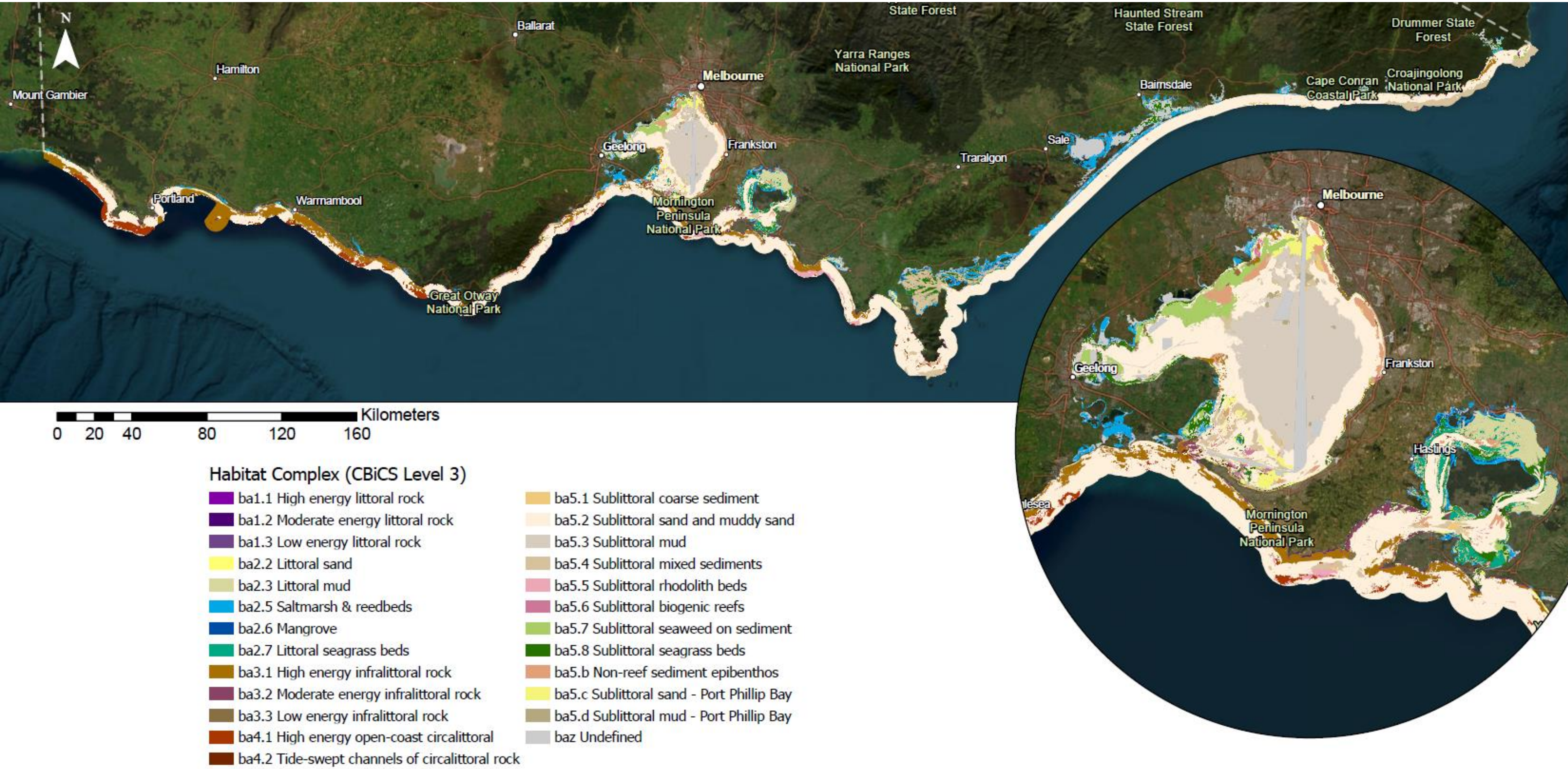


Figure A3. Statewide habitat map (Vector Polygon Format; resolution 25m). Developed from a mosaic of previous mapping products, aerial imagery, field observation records, environmental variables and novel machine learning methods that model and predict habitat distributions (see Table 3 for a list of compiled mapping products).

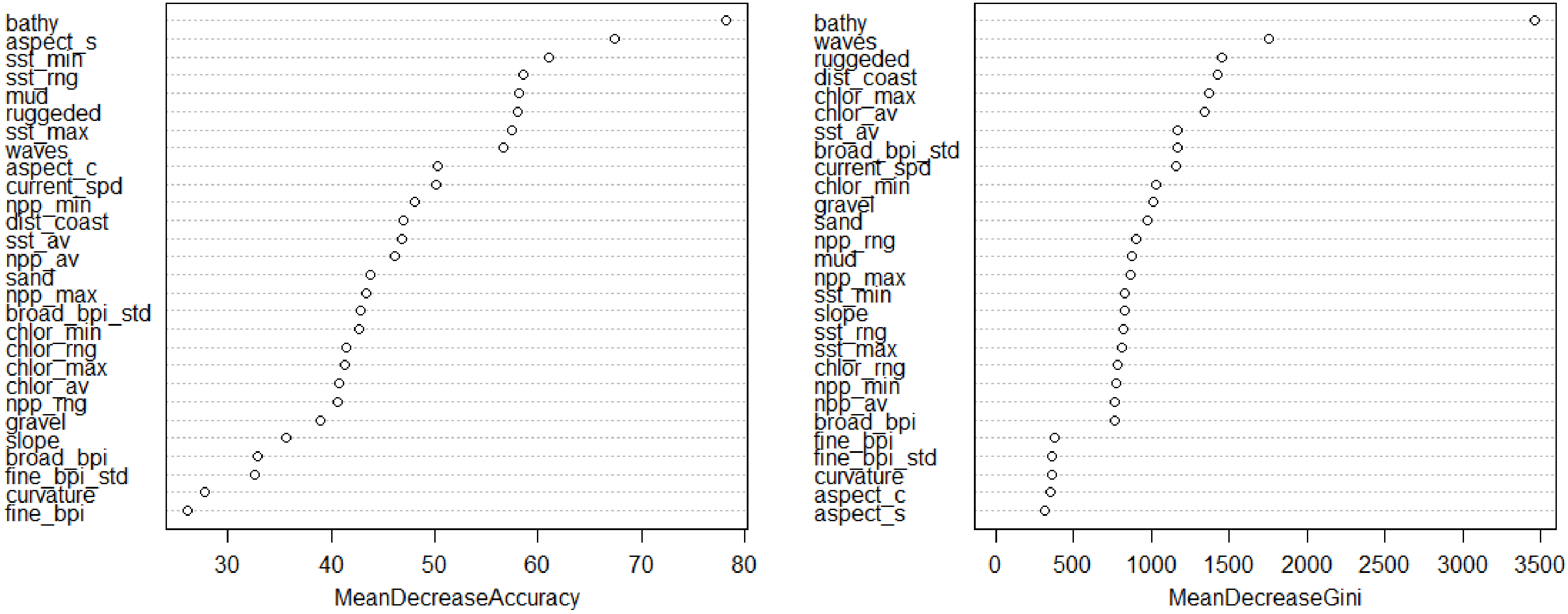


Figure A4. Environmental predictor importance from the Random Forest model. Bathymetry, waves, aspect, sea surface temperature and ruggedness are considered important predictors in the model.

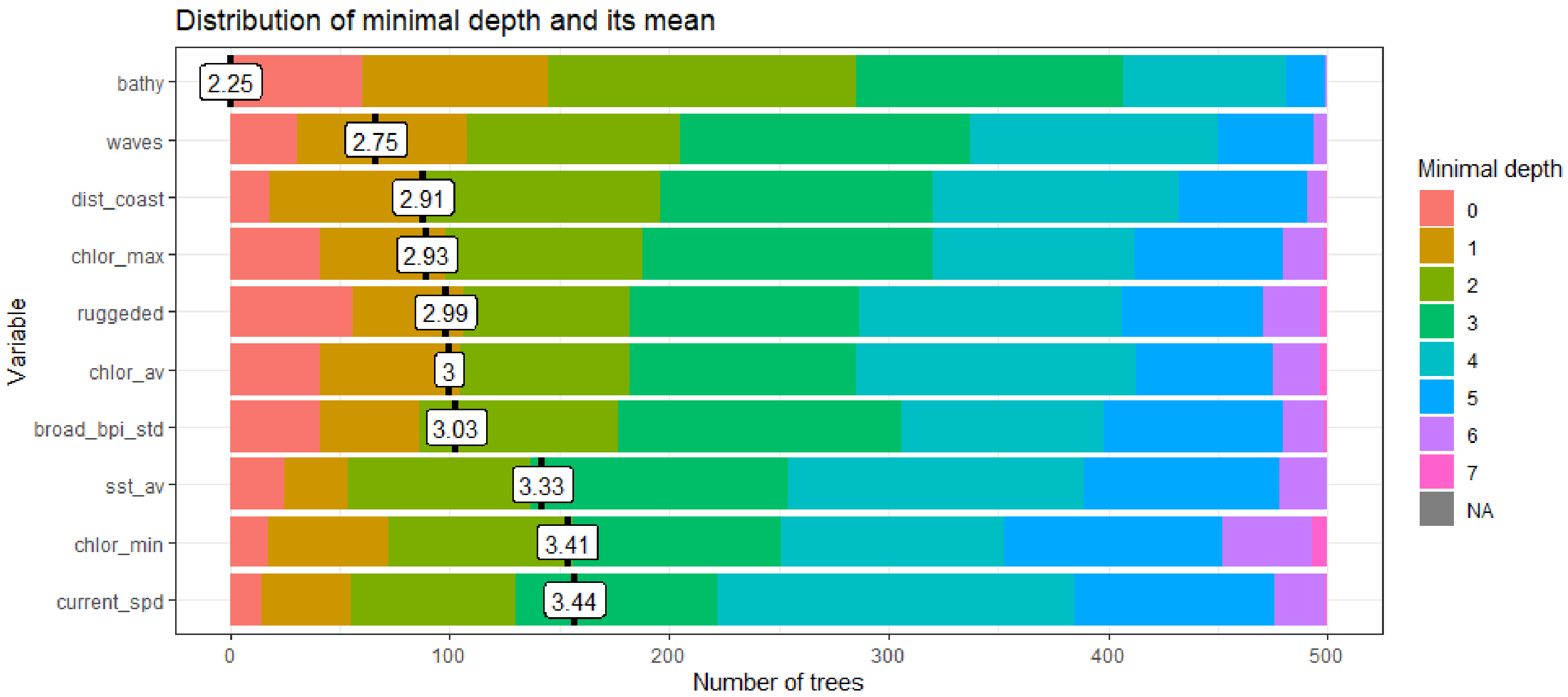


Figure A5. Environmental predictor importance from the Random Forest model.

Table A1. Ground-truth records (CBiCS Level 3 – Habitat Complex) across Victoria's state waters sampled per year from 1949 to 2019. A total of 32,998 records were used in the modelling process, with totals per year and per habitat complex category recorded. Note that some records may have been excluded in the model output due to modelling criteria.

Code	Habitat Complex (Level 3)	1949	1969	1970	1995	1996	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2019	Total
ba1.1	High energy infralittoral rock	92		14									8	233	61	35		9	12	11	8	17	3			710	1213
ba1.2	High energy littoral rock		1	7										37	21	2		5	3	3	4	6	2			46	137
ba1.3	High energy open coast circalittoral rock		19	5									5	24		9		7	10	8	7	10	11			38	153
ba2.1	Littoral coarse sediment																									1	1
ba2.2	Littoral mud																									208	208
ba2.3	Littoral sand																									174	174
ba2.5	Low energy infralittoral rock																			3953							3953
ba2.6	Low energy littoral rock																			80							80
ba3.1	Mangrove				3	205	86	207	271	363	274	114	256	251	903	393	684	1255	1483	352	31	68	257	68	131	49	7704
ba3.2	Moderate energy infralittoral rock				1	6	43	77	399	80	82	44	62	24	49			29	40	178	27	8	36	31		15	1231
ba3.3	Moderate energy littoral rock							3				24	25	31				99	31	22	23	50		24	2	7	341
ba4.1	Non-reef sediment epibenthos					32	9							1	1837	297	1440	7	70					18	174	17	3902
ba4.2	Saltmarsh and reedbeds											5								7	31					2	45
ba5.1	Sublittoral biogenic reefs					18	22	2							56		6	9	9	1	32			20	60	22	257
ba5.2	Sublittoral coarse sediment					84	75	6					44	107	697	219	800	680	701	1069	766		9	14	102	152	5525
ba5.3	Sublittoral mixed sediments							4					6	29	37	17				15	52			13	12	57	242
ba5.4	Sublittoral mud					2									213			1	36	1	9			8	218	106	594
ba5.5	Sublittoral mud 2 - Port Phillip Bay					41	1								18	36	39		8				3				146
ba5.6	Sublittoral rhodolith beds								83						53			5	3	3	5				1	4	157
ba5.7	Sublittoral sand 2 - Port Phillip Bay					4		4				2			91	7	55	140	43	518	572			9	7	2	1454
ba5.8	Sublittoral sand and muddy sand					1		218	1715	30	36	25	119	296	328	175	38	139	393	692	346	4	10	89	78		4732
ba5.b	Sublittoral seagrass beds					12						2			17	55	133	76	30	184	156			10	1		676
ba5.c	Sublittoral seaweed on sediment											49															49

Code	Habitat Complex (Level 3)	1949	1969	1970	1995	1996	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2019	Total
ba5.d	Tide-swept channels of circalittoral rock											24															24
	Total	92	20	26	4	405	236	521	2468	473	392	289	525	1033	4381	1245	3195	2461	2872	7097	2069	163	331	304	786	1610	**32998**

Table A2. Environmental predictor included in the habitat map modelling. All environmental predictors were processed in raster format, to a consistent coordinate system (GDA2020 Vicgrid), extent and resolution (10m) in ArcGIS Pro (ESRI 2021).

Environmental Predictors	Description
Bathymetry	Digital Elevation Model (DEM) created from LiDAR and multibeam at 10m resolution. (Reference: Victorian Coastal Digital Elevation Model 2021 (VCDEM))
Aspect - East	ArcGIS Pro Benthic Terrain Modeler (Walbridge et al. 2018), 10m resolution
Aspect - North	ArcGIS Pro Benthic Terrain Modeler (Walbridge et al. 2018), 10m resolution
Slope	ArcGIS Pro Benthic Terrain Modeler (Walbridge et al. 2018), 10m resolution
Curvature	ArcGIS Pro Benthic Terrain Modeler (Walbridge et al. 2018), 10m resolution
Terrain Ruggedness (VRM)	ArcGIS Pro Benthic Terrain Modeler (Walbridge et al. 2018), 10m resolution
Bathymetric Position Index (BPI) - Broad	ArcGIS Pro Benthic Terrain Modeler (Walbridge et al. 2018), 10m resolution
Bathymetric Position Index (BPI) - Fine	ArcGIS Pro Benthic Terrain Modeler (Walbridge et al. 2018), 10m resolution
Bathymetric Position Index (BPI) - Std	ArcGIS Pro Benthic Terrain Modeler (Walbridge et al. 2018), 10m resolution
Distance to Coast	ArcGIS Euclidean distance tool 10m resolution (coastline = Victorian Coastline 2008; https://datashare.maps.vic.gov.au/search?q=uuid%3D9df9d72c-5e52-52c9-9796-f59cbea17b28**)**
Sediment - Gravel.	Percent of Gravel (0-100%). Natural Neighbour Interpolation (NNI) was used in ArcGIS Pro to resample the raster data sets to the finer resolution of 10m (matching the DEM layer). The dataset provides the spatially continuous data of the seabed gravel content (sediment fraction >2000 µm) expressed as a weight percentage ranging from 0 to 100%, presented in 0.01 decimal degree resolution raster format. Citation: Li, J.; Heap, A.D.; Potter, A.; Huang, Z. (2011a): Seabed Gravel Content Across the Australian Continental EEZ, 2011. Dataset: http://pid.geoscience.gov.au/dataset/ga/71981
Sediment - Sand	Percent of Sand (0-100%). Natural Neighbour Interpolation (NNI) was used in ArcGIS Pro to resample the raster data sets to the finer resolution of 10m (matching the DEM layer). This dataset provides the spatially continuous data of the seabed sand content (sediment fraction 63-2000 mm) expressed as a weight percentage ranging from 0 to 100%, presented in 0.01 decimal degree resolution raster format. Citation: Li, J.; Heap, A.; Potter, A.; Huang, Z. (2011b): Seabed Sand Content Across the Australian Continental EEZ, 2011. Dataset. http://pid.geoscience.gov.au/dataset/ga/71982

Sediment - Mud	Percent of Mud (0-100%). Natural Neighbour Interpolation (NNI) was used in ArcGIS Pro to resample the raster data sets to the finer resolution of 10m (matching the DEM layer). This dataset provides the spatially continuous data of seabed mud content (sediment fraction < 63 Âµm) expressed as a weight percentage ranging from 0 to 100%, presented in 0.01 decimal degree resolution raster format. Citation: Li, J.; Heap, A.D; Potter, A.; Huang, Z.; Daniell, J.J. (2011c): Seabed Mud Content Across the Australian Continental EEZ, 2011. Dataset. http://pid.geoscience.gov.au/dataset/ga/71977
Chlorophyl a - Range	IMOS (Integrated Marine Observing System). (2022a). IMOS - SRS - MODIS - 01 day - Chlorophyll-a concentration (GSM model). 1 km resolution, Annual composites of Year 2009 - 2019. Retrieved from: https://catalogueimos.aodn.org.au/geonetwork/srv/api/records/f73daf07-eb81-4995-a72aca903834509f
Chlorophyl a - Mean	IMOS (Integrated Marine Observing System). (2022a). IMOS - SRS - MODIS - 01 day - Chlorophyll-a concentration (GSM model). 1 km resolution, Annual composites of Year 2009 - 2019. Retrieved from: https://catalogueimos.aodn.org.au/geonetwork/srv/api/records/f73daf07-eb81-4995-a72aca903834509f
Chlorophyl a - Max	IMOS (Integrated Marine Observing System). (2022a). IMOS - SRS - MODIS - 01 day - Chlorophyll-a concentration (GSM model). 1 km resolution, Annual composites of Year 2009 - 2019. Retrieved from: https://catalogueimos.aodn.org.au/geonetwork/srv/api/records/f73daf07-eb81-4995-a72aca903834509f
Chlorophyl a - Min	IMOS (Integrated Marine Observing System). (2022a). IMOS - SRS - MODIS - 01 day - Chlorophyll-a concentration (GSM model). 1 km resolution, Annual composites of Year 2009 - 2019. Retrieved from: https://catalogueimos.aodn.org.au/geonetwork/srv/api/records/f73daf07-eb81-4995-a72aca903834509f
Net primary productivity (NPP) - Range	IMOS (Integrated Marine Observing System). (2022b). IMOS - SRS - MODIS - 01 day - Net Primary Productivity (GSM model and Eppley-VGPM algorithm).1 km resolution, Annual composites of Year 2009 – 2019, Retrieved from: https://catalogue-imos.aodn.org.au/geonetwork/srv/api/records/27cc65c0-d453-4ba3-a0d6-55e4449fee8c
Net primary productivity (NPP) - Mean	IMOS (Integrated Marine Observing System). (2022b). IMOS - SRS - MODIS - 01 day - Net Primary Productivity (GSM model and Eppley-VGPM algorithm).1 km resolution, Annual composites of Year 2009 – 2019, Retrieved from: https://catalogue-imos.aodn.org.au/geonetwork/srv/api/records/27cc65c0-d453-4ba3-a0d6-55e4449fee8c
Net primary productivity (NPP) - Max	IMOS (Integrated Marine Observing System). (2022b). IMOS - SRS - MODIS - 01 day - Net Primary Productivity (GSM model and Eppley-VGPM algorithm).1 km resolution, Annual composites of Year 2009 – 2019, Retrieved from: https://catalogue-imos.aodn.org.au/geonetwork/srv/api/records/27cc65c0-d453-4ba3-a0d6-55e4449fee8c
Net primary productivity (NPP) - Min	IMOS (Integrated Marine Observing System). (2022b). IMOS - SRS - MODIS - 01 day - Net

	Primary Productivity (GSM model and Eppley-VGPM algorithm).1 km resolution, Annual composites of Year 2009 – 2019, Retrieved from: https://catalogue-imos.aodn.org.au/geonetwork/srv/api/records/27cc65c0-d453-4ba3-a0d6-55e4449fee8c
Sea surface temperature (SST) - Range	IMOS (Integrated Marine Observing System) (2022c). IMOS - SRS - SST - L3S - Single Sensor - 1 day - day time - Australia. Annual composites of Year 2009 – 2019, 2 km resolution. Retrieved from: https://catalogueimos.aodn.org.au/geonetwork/srv/api/records/8bd3fe33-fd98-4307-ad23-424ad9a2907b
Sea surface temperature (SST) - Mean	IMOS (Integrated Marine Observing System) (2022c). IMOS - SRS - SST - L3S - Single Sensor - 1 day - day time - Australia. Annual composites of Year 2009 – 2019, 2 km resolution. Retrieved from: https://catalogueimos.aodn.org.au/geonetwork/srv/api/records/8bd3fe33-fd98-4307-ad23-424ad9a2907b
Sea surface temperature (SST) - Max	IMOS (Integrated Marine Observing System) (2022c). IMOS - SRS - SST - L3S - Single Sensor - 1 day - day time - Australia. Annual composites of Year 2009 – 2019, 2 km resolution. Retrieved from: https://catalogueimos.aodn.org.au/geonetwork/srv/api/records/8bd3fe33-fd98-4307-ad23-424ad9a2907b
Sea surface temperature (SST) - Min	IMOS (Integrated Marine Observing System) (2022c). IMOS - SRS - SST - L3S - Single Sensor - 1 day - day time - Australia. Annual composites of Year 2009 – 2019, 2 km resolution. Retrieved from: https://catalogueimos.aodn.org.au/geonetwork/srv/api/records/8bd3fe33-fd98-4307-ad23-424ad9a2907b
Currents	Average current speed. 25-year hindcast model of annual current speeds from 1990 to 2015. Water Tech. Young, MA, Porskamp, P, Critchell, K, Treml, E, Ierodiaconou, D, Pocklington, JB, Sams, MA (2022) *Statewide assessment of Victorian marine protected areas using existing data*. Parks Victoria Technical Series 118, Parks Victoria, Melbourne.
Waves	Max Wave Orbital Velocity range between 2006 – 2015, at 50 m resolution. Data source: Liu, J., Meucci, A., Liu, Q., Babanin, A. V., Ierodiaconou, D., & Young, I. R. (2022), The wave climate of Bass Strait and south-east Australia. Ocean Modelling, 172, 101980. https://doi.org/10.1016/j.ocemod.2022.101980

Table A3. Mapping layers incorporated into the composite statewide marine habitat map.

Layer name	Information	Reference
Corangamite Coast Marine Habitat December 2009 (ANZVI0803005530)	This polygon layer represents shallow marine habitats in the Corangamite catchment coastal region mapped from aerial photography and underwater video ground-truthing. This mapping was funded by the Natural Heritage Trust to increase the capacity of natural resource managers to make informed decisions regarding asset identification, risk assessment and establishment of management action targets for nearshore marine habitats in the region. This layer combines two datasets for east and west Corangamite into a single layer. Included in composite map. Other mapped areas in this layer include; Barwon Blue Marine Sanctuary 2004, Eagle Rock Marine Sanctuary 2003, Port Phillip Heads Marine National Pak and Point Lonsdale 2004, Point Danger Marine Sanctuary 2003, Point Addis Marine National Park 2004, Marengo Reefs Marine Sanctuary 2004 (ANZVI0803004055) Reference: Ball, D. and Blake, S. (2007) Shallow habitat mapping in Victorian Marine National Parks and Sanctuaries, Volume 2: Eastern Victoria. Parks Victoria Technical Series No. 37. Parks Victoria, Melbourne.	Ball, David & Blake, Sean & Young, Peter & Coots, Alister. (2010). Corangamite Nearshore Marine Habitat Mapping & Assessment. 10.13140/RG.2.2.23377.53600. Available:https://datashare.maps.vic.gov.au/search?q=uuid%3D47eb5762-d426-525e-a85c-586509fe006b
East Gippsland Marine Habitats November 2009 (ANZVI0803003974)	This polygon layer represents marine habitat in the East Gippsland region mapped from satellite imagery and aerial photography with underwater video ground-truthing. The mapping was funded by Natural Heritage Trust to increase the capacity of natural resource managers to make informed decisions regarding asset identification, risk assessment, and management action targets for nearshore marine habitats in the region. Included in composite map. Other mapped areas in this layer include Cape Howe Marine National Park 2004, Point Hicks Marine National Park 2004. Reference: Ball, D. and Blake, S. (2007) Shallow habitat mapping in Victorian Marine National Parks and Sanctuaries, Volume 2: Eastern Victoria. Parks Victoria Technical Series No. 37. Parks Victoria, Melbourne.	Ball, David & Blake, Sean & Young, Peter & Coots, Alister. (2010). East Gippsland Nearshore Marine Habitat Mapping & Assessment. 10.13140/RG.2.2.16745.29282. Available:https://datashare.maps.vic.gov.au/search?q=uuid%3D3d7e5f97-386c-5c5f-b840-a1c735b35413
Discovery Bay Marine National Park habitat mapping 2006 (ANZVI0803004053)	Included in composite map. Shallow marine habitat mapping at Discovery Bay from aerial photography and underwater video. Mapped to approximately 10m depth, but unable to define the seaward boundary of reef band as accurately as some other MNP sites	Ball, D. and Blake, S. (2007) Shallow habitat mapping at Victorian Marine National Parks and Sanctuaries. Volume 1: Western Victoria, Parks Victoria Technical Series No. 36.
Portland Coastal Habitats (ANZVI0803004236)	Included in composite map. The layer was created by plotting shoreline types and coastal habitats onto clear film overlaying the aerial photography. Wherever necessary, shoreline types and coastal habitats, with the exception of	Ball (1999). Portland Coastal Habitats. Department of Environment Land Water and Planning.

	subtidal habitats, were verified in the field. The plotted habitat was manually digitised and then transformed into real world coordinates	
Corner Inlet Mapping Marine National Park North and South 2004 (ANZVI0803004051)	Used to verify current mapping outputs. Corner Inlet Marine National Park was mapped through a combination of aerial photography interpretation and ground-truthing with underwater video. QASCO Pty Ltd flew and ortho-rectified aerial photography for Corner Inlet MNP for the MNP mapping project. The photography was flown on 18thFebruary 2004 at about 1550 close to low tide.	Ball, D. and Blake, S. (2007) Shallow habitat mapping in Victorian Marine National Parks and Sanctuaries, Volume 2: Eastern Victoria. Parks Victoria Technical Series No. 37. Parks Victoria, Melbourne.
Merri Marine Sanctuary 2004 (ANZVI0803004058	Included in composite map. Digital ortho-rectified aerial photography for Merri MS flown by QASCO Pty Ltd for the City of Warrnambool. The photography was part of a larger digital mosaic of the City of Warrnambool flown on 1st December 2004.Older aerial photography flown by QASCO in 1992 was used to assist in interpreting habitat types. Shallow and intertidal habitats at this site were manually digitised from the digital photography. The habitat classification system applied to the mapping is presented in Ball, D., Blake, S. and Plummer, A. (2006) Review of marine classification systems, Parks Victoria Technical Series No. 26.	Ball, D. and Blake, S. (2007) Shallow habitat mapping at Victorian Marine National Parks and Sanctuaries. Volume 1: Western Victoria, Parks Victoria Technical Series No. 36.
Western Port Bay Biotope Mapping	Included in composite map areas that are depicted at level 3 or above. Level 2 or Level 1 were excluded (habitat map name = WPB_Biotopes_160829). Other layers that were part of this mapping portfolio (i.e. Gippsland Lakes (GL_Biotopes_20161213), Port Phillip Bay (PPB_Biotopes_160722.shp) were compared to the resulting map. Port Phillip habitat were already accounted for in the Port Phillip Bay Habitat Map 2021 (below).	Fathom Pacific (2016) CBiCS-Mapping.
Central Victoria Coastal Habitats (ANZVI0803004135)	Used when not captured by above layers. Excluded "Intertidal Mud-Sand Flat", "Mangroves", "Saltmarsh" and sandy areas removed around French Island due to misalignment with ground-truthed biotope records in a number of areas. This polygon layer identifies shoreline types and habitats in the coastal and shallow subtidal region from Cape Otway to Cape Liptrap (excludes Wilsons Prom and Port Phillip Bay) and Shallow Inlet/Corner Inlet/Nooramunga. The habitats were mapped from colour aerial photography in conjunction with ground-truthing field surveys. Shoreline categories were defined on the basis of the information requirements of oil spill contingency planning and response personnel. This layer was created to assist oil spill planning and response and for inclusion in the Oil Spill Response Atlas. The layer is a combination of all coastal mapping for the Oil Spill Response Atlas program between 1990-98 in Victoria.	Victoria Department of Transport (1999) Central Victoria Coastal Habitats. Marine Pollution DEDJTR, Victoria.

Mallacoota Coastal Habitats (ANZVI0803004235)	Included in composite map. This polygon layer identifies shoreline types and habitats in the coastal and shallow subtidal region. The shoreline types and habitats were mapped through an interpretation of colour aerial photography in conjunction with field observations to ground-truth the photography. Shoreline categories were defined on the basis of the information requirements of oil spill contingency planning and response personnel.	Ball (1999). Mallacoota Coastal Habitats. Department of Environment Land Water and Planning
Western Port Rhodolite (ANZVI0803005430) & Western Port Biogenic Reefs	Included in composite map. The Western Port Bryozoan Reef Fathom Pacific 2020 has been simplified to fit the scale of mapping needed. The mapping was done through video surveys targeting Western Port, surveyed between December 2011 and March 2012. Rhodoliths were observed distributed over an area of approximately 0.5 km2 near the eastern entrance and depths ranged from 1.1-8.6 m.	Blake, S., Ball, D., Coots, A., Smith, T. (2013) Marine video survey of Western Port. Fisheries Victoria Technical Report No. 176, Department of Primary Industries, Queenscliff, Victoria, Australia. Fathom Pacific (2020). Western Port Bryozoan Reefs Project: 2020 Macrofauna Biodiversity Report Annual Report. Report to AGL and La Trobe University by Fathom Pacific Pty Ltd.
Port Phillip Bay Habitat Map 2021 (ANZVI0803009278)	Used to verify current mapping outputs. The statewide map precedes the former 2021 Port Phillip Bay Habitat map, which provides predictions with consistent resolution and environmental predictors across the state. The state map applies a cautious approach whereby habitats and regions that are well mapped are mosaiced into the final map (e.g. seagrass in Port Phillip Bay is more conservatively represented in the statewide map with data used from Blake & Ball 2001; PPB_Biotopes_160722.shp).	Mazor, T., Edmunds, M., Flynn, A., Ferns, L. DELWP (2021). Port Phillip Bay Habitat Map. Habitat Complex Modelling (CBiCS Level 3). The State of Victoria Department of Environment, Land, Water and Planning 2021. Available:https://datashare.maps.vic.gov.au/search?q=uuid%3Ddf94da5d-ae99-535e-9f12-8be535c0e293 https://www.marineandcoasts.vic.gov.au/__data/assets/pdf_file/0031/537169/Mazor-et-al-2021_Port-Phillip-Bay-CBiCS-Habitat-Model.pdf Blake, S. and Ball, D. (2001). Victorian Marine Habitat Database: SeagrasMapping of Port Phillip Bay. Geospatial Systems Section, Marine and Freshwater Resources Institute Report No. 39. Marine and Freshwater Resources Institute: Queenscliff.
Saltmarsh and Mangrove Habitats	Included in composite map. Mangroves and coastal saltmarsh of Victoria was mapped and attributed to CBiCS by Dr. Matt Edmunds, Australian Marine Ecology	Boon, P.I. et al. (2011). Mangroves and coastal saltmarsh of Victoria: distribution, condition, threats and management. Report to DSE, Bendigo. 513 pp. Attributed to CBiCS by Dr. Matt Edmunds, Australian Marine Ecology

DELWP 2021 Statewide Marine Habitat Map 2021 (ANZVI0803009286)	Used to verify current mapping outputs and stamped in Corner Inlet and Nooramunga habitats as there is a lack of level 3 ground truthing data in this region to depict the habitat types. Combined Port Phillip Bay habitat model developed by DELWP 2021 and Open Coast Deakin marine mapping campaign January 2019. The Open Coast statewide marine habitat map (excluding PPB) developed by Deakin Marine Mapping lab using a range of techniques including digitisation of polygons and has been compiled using a compilatiom of various datasets including Boon et al. (2011). Deakin Marine Mapping (Young M et al, 2018). GeoHab Victoria Estuaries Geomorphology (2010). Deakin Marine Mapping (Zavalas, R et al. 2018), DELWP wetlands (1994), Monk et al 2011, Roob and Ball (1997), Ford et al 2016, Edmunds and Flynn (2015), Blake and Ball (2001), Poore (1992), Cohen et al (2000). The map has later been reclassified to CBICS habitat classification scheme at broad-scale level 2 and 3.	DELWP (2021). Statewide Marine Habitat Map 2021. ANZVI0803009286. Department of Environment, Land, Water & Planning 2022. Available:https://datashare.maps.vic.gov.au/search?q=uuid%3D545463df-853e-5c13-b585-0785c8e5e357 Monk, J. Pope, A. Ierodiaconou, D. Otera, K. Mount, R. (2011). Corner Inlet and Nooramunga Habitat Mapping Project. Deakin University, Warrnambool, Victoria, Australia. 60 pages.

Table A4. The Random Forest habitat model accuracy.

	ba11	ba12	ba13	ba21	ba22	ba23	ba25	ba26	ba31	ba32	ba33	ba41	ba42	ba51	ba52	ba53	ba54	ba55	ba56	ba57	ba58	ba5b	ba5c	ba5d	Class Error
ba11	1159	2	1	0	23	0	1	0	22	0	0	0	0	0	2	0	0	0	0	0	3	0	0	0	0.0445
ba12	13	112	1	0	1	2	0	1	1	1	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0.1825
ba13	2	0	140	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	1	8	0	0	0	0.0850
ba21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	NA
ba22	106	2	1	0	45	1	8	0	0	3	1	0	0	0	5	0	0	0	0	0	36	0	0	0	0.7837
ba23	0	0	0	0	0	107	2	3	0	1	0	0	0	0	0	1	0	0	0	0	60	0	0	0	0.3851
ba25	2	0	0	0	2	2	3905	6	1	1	0	1	0	0	4	0	0	0	0	3	26	0	0	0	0.0121
ba26	0	1	1	0	0	10	7	41	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0	0	0.4875
ba31	24	0	0	0	0	0	0	0	7372	89	0	46	1	6	147	0	3	4	0	4	4	4	0	0	0.0431
ba32	2	0	0	0	0	0	0	0	112	1045	0	0	2	0	33	0	0	2	0	3	28	4	0	0	0.1511
ba33	0	0	7	0	1	0	0	0	1	1	279	0	0	0	14	3	0	0	0	6	27	2	0	0	0.1818
ba41	0	0	0	0	0	0	0	0	47	0	1	3608	0	6	153	0	50	10	0	21	0	6	0	0	0.0753
ba42	0	0	0	0	0	0	0	0	3	4	0	0	24	4	8	0	1	0	0	0	0	1	0	0	0.4667
ba51	0	0	0	0	0	0	1	0	28	0	1	12	4	131	48	3	14	1	0	4	8	2	0	0	0.4903
ba52	2	0	0	0	0	0	1	0	258	28	14	226	4	14	4552	4	16	5	3	54	278	66	0	0	0.1761
ba53	0	0	0	0	0	0	3	0	0	0	2	1	0	8	34	102	4	0	0	20	64	2	0	2	0.5785
ba54	0	0	0	0	0	0	0	0	9	1	0	61	1	18	77	9	379	1	1	11	16	6	4	0	0.3620
ba55	0	0	0	0	0	0	0	0	8	3	0	17	0	0	9	0	1	101	0	3	4	0	0	0	0.3082
ba56	0	0	0	0	0	0	0	0	1	0	0	0	0	0	11	0	3	1	113	0	22	6	0	0	0.2803
ba57	0	0	0	0	0	0	2	0	8	4	3	53	0	3	52	9	9	2	2	1205	77	23	2	0	0.1713
ba58	2	0	1	0	0	6	18	0	12	36	10	0	0	6	247	23	1	2	8	70	4282	7	1	0	0.0951
ba5b	0	0	0	0	0	0	0	0	4	3	1	25	4	1	122	0	6	0	4	25	16	463	2	0	0.3151
ba5c	0	0	0	0	0	0	0	0	1	0	0	0	0	0	11	1	0	0	1	0	2	1	32	0	0.3469
ba5d	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	1	0	0	0	0	0	2	13	0.4583
																									Overall Accuracy 89%

Table A5. ArcGIS Pro (ESRI 2021) processing steps to derive habitat map from raster model output to polygon layer at 25m resolution.

Steps	ArcGIS Pro Tools
Raster processing	
1	Make Raster Layer (Data Management Tools; input .tiff layer from random forest model)
2	Int (Spatial Analyst Tools; Create Raster Layer ready for polygonization)
3	Raster to Polygon (Conversion Tools)
Polygon processing	
4	Simplify Polygon (Cartography Tools; Retain critical bends (Wang-Müller); Simplification Tolerance = 25m)
5	Eliminate Polygon Part (Data Management Tools; Area 250 square metres)
6	Smooth Polygon (Cartography Tools; smoothing tolerance = 25m)
7	Join Important Features Spatial Tools (Merge, Erase, Union) Spatial layers in Table 3 were examined and incorporated into the statewide composite map.
8	Alignment with state waters 3nm boundary and coastline (Victorian Coastline 2008 ANZVI0803004745).
9	Repair Geometry (Data Management Tools)

deeca.vic.gov.au