11-2019

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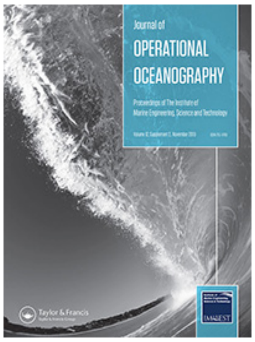

Journal of Operational Oceanography

ISSN: 1755-876X (Print) 1755-8778 (Online) Journal homepage: https://www.tandfonline.com/loi/tjoo20

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JOURNAL OF OPERATIONAL OCEANOGRAPHY
2019, VOL. 12, NO. S2, s47–s56
https://doi.org/10.1080/1755876X.2018.1529714

A new 30 meter resolution global shoreline vector and associated global islands database for the development of standardized ecological coastal units

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ABSTRACT
A new 30-m spatial resolution global shoreline vector (GSV) was developed from annual composites of 2014 Landsat satellite imagery. The semi-automated classification of the imagery was accomplished by manual selection of training points representing water and non-water classes along the entire global coastline. Polygon topology was applied to the GSV, resulting in a new characterisation of the number and size of global islands. Three size classes of islands were mapped: continental mainlands (5), islands greater than 1 km^2 (21,818), and islands smaller than 1 km^2 (318,868). The GSV represents the shore zone land and water interface boundary, and is a spatially explicit ecological domain separator between terrestrial and marine environments. The development and characteristics of the GSV are presented herein. An approach is also proposed for delineating standardised, high spatial resolution global ecological coastal units (ECUs). For this coastal ecosystem mapping effort, the GSV will be used to separate the nearshore coastal waters from the onshore coastal lands. The work to produce the GSV and the ECUs is commissioned by the Group on Earth Observations (GEO), and is associated with several GEO initiatives including GEO Ecosystems, GEO Marine Biodiversity Observation Network (MBON) and GEO Blue Planet.

ARTICLE HISTORY
Received 18 April 2018
Accepted 25 September 2018

KEYWORDS
Coastline; coastal ecosystems; global shoreline mapping; global islands database; Blue Planet

Introduction

Coastal classification and mapping at management-appropriate scales have never been more important. In 2015, 193 countries agreed to the United Nation's 2030 Agenda for Sustainable Development and its seventeen Sustainable Development Goals (SDGs: http://www.un.org/sustainabledevelopment/sustainable-development-goals/). One of these SDGs (Life Below Water, SDG 14) calls for the sustainable management and protection of marine and coastal ecosystems (Visbeck et al. 2014). To achieve that goal, a related target is to conserve, by 2020, at least 10% of coastal and marine areas consistent with national and international law and using the best available scientific information (Sala et al. 2018). These ambitious goals are more easily addressed if: (1) a sound and globally comprehensive inventory of coastal and marine ecosystems exists; and (2) criteria are available and implementable for determining which 10% of marine and coastal ecosystems should be protected. On the second point, conservation priority setting is now a relatively mature discipline, having evolved from early thinking about simple reserve selection algorithms (e.g. Pressey et al. 1993) to conservation NGO-derived, practitioner-focused, 'conservation blueprint' approaches applied at global, ecoregional, and site scales (Groves 2003; Asaad et al. 2016, 2018; Gelcich et al. 2018). However, standardised, globally-comprehensive, and

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management-scaled inventories of global marine and coastal ecosystems are not yet available.

To address this lack, the Group on Earth Observations (GEO, https://www.earthobservations.org/index.php) has commissioned the development of standardised, rigorous, and practical ecosystem classifications and maps for terrestrial, freshwater, and marine ecosystems in the GEO Global Ecosystems Initiative (GEO ECO, https://www.earthobservations.org/activity.php?id=116). In response to this charge, the U.S. Geological Survey (USGS) and Esri have partnered with international experts in a public/private/academic partnership to produce a global ecological land units map (ELUs; Sayre et al. 2014) and a global ecological marine units map (EMUs; Sayre et al. 2017). The EMUs resource is a first-of-its-kind, true 3D, globally comprehensive, data-derived map which partitions the global ocean into 37 volumetric regions based on differences in temperature, salinity, dissolved oxygen, nitrate, phosphate, and silicate. The EMUs do intersect the land, but they are essentially large volumetric ocean regions with a spatial resolution of 1/4° (approximately 27 km by 27 km at the equator). While this spatial resolution is appropriate for global and regional characterisations of open ocean regions, it is not adequate for the characterisation of finer, often linear, densely-populated coastal features. The team that produced the EMUs are therefore developing a separate and independent delineation of global ecological coastal units (ECUs) using the best available globally comprehensive data at the finest possible spatial resolution.

The global coastal zone is an important area from a variety of perspectives, and includes the coastline itself, terrestrial features on the landward side of the coastline, and aquatic features on the seaward side. On the most basic level, the coastline therefore separates terrestrial from marine environments, and by extension, marine vs. terrestrial biodiversity. The coastal zone is a place of great importance to people, with an estimated 40% of the world's population currently living within 100 km of a coast and by 2020 a projected increase to 75% (UN 2010; Neumann et al. 2015). Given the ubiquity of humans in the coastal zone and their reliance on its goods and services, an understanding of coastal zone ecosystems is therefore required to manage them sustainably for current and future generations.

In a classic presentation on geographic variation in coastal features, Davies (1980) reduced the controls on coastal development to three broad factors: land origin physical factors, sea origin physical factors, and biological factors along the shoreline. He identified the existence of broad patterns in coastal development on a global scale, and emphasised the importance of climate factors such as precipitation, insolation, evaporation, frost, and wind on coastal development. Davies' (1980) work built on the pioneering classification effort of Inman and Nordstrom (1971) based on genetic (tectonic) origins of coasts. They characterised tectonic origin as the most macro level, primary control on coastal development, and classified collision coasts, trailing-edge coasts, and protected marginal seas coasts. Their treatment included a rigorous discussion of scale and coastal zone dimensions, and also recognised the importance of macro-scale river discharge as a key part of coastal evolution. Inman and Nordstrom (1971) also proposed a very practical geomorphological classification of coasts reflecting tectonic origin which has never been implemented globally using available data. Finally, they included 'illustrative' global maps of classified coastlines such as were popular in the pre-GIS mapping era, where researchers often used both limited data and personal geographic knowledge to elaborate surprisingly accurate sketches of Earth's land and sea features (e.g. Hammond 1954; Raisz and Atwood 1957; Murphy 1968; Bridges 1990).

Boyd et al. (1992) evolved the science of coastal classification through consideration of the erosional and depositional setting. They developed a conceptual framework for describing erosional and depositional coastlines based on the relative influence of waves, tides, and rivers. They constructed a ternary diagram to conceptually identify the occurrences of deltas, strandplains, tidal flats, etc. based on a consideration of wave, tide, and river regimes. Expanding on this logic, and developing proxy measurements for the three factors, others have mapped coastal depositional environments in Australia (Harris et al. 2002) and Asia (Vakarelov and Ainsworth 2012). Nyberg and Howell (2016) have extended these efforts to produce the first globally-comprehensive and quantitatively-mapped characterisation of non-erosional and erosional coastlines, subdividing the latter into wave-dominated, tide-dominated, and fluvial-dominated coastal areas. Coastal sediment environments have also been mapped by extraction of documented rock, sand, and mud features from nautical charts (Neilson and Costello 1999).

These tectonic, geomorphological, and hydrodynamic coastal zone classification efforts are complemented by other approaches which emphasise characterisation of the biochemical environment (Crossland et al. 2006), the biota (FGDC 2012) and the degree of alteration of natural coastal environments by humans (Alcantara-Carrio et al. 2014). The variety of coastal characterisation approaches reflect differences in their intended purposes and audiences, scales, and geographic coverage.

Although the approach to coastal classification is varied, the marine domain (marine waters and the seabed beneath) and the terrestrial domain are generally regarded as separated at the coastline. Coastline position is temporally dynamic, with tidal, seasonal, and long-term variations (Boak and Turner 2005). Mapping the position of the coastline from a satellite image produces what is called an instantaneous coastline, i.e. the coastline position at any point in time (Kalaranjini and Ramakrishnan 2016). The instantaneous coastline vector is then often reconciled to a tidal datum which calibrates coastline position against measurements of average high and low tide positions (Boak and Turner 2005).

The main objective of this paper is to present a new standardised global shoreline vector (GSV) and derived global islands database developed from 2014 Landsat satellite imagery. The new coastline resource will be used as a primary domain separator between terrestrial and marine environments in a subsequent effort to map the GEO-commissioned global ecological coastal units (ECUs) as described above. The GSV was developed because existing characterisations of the global coastline were inadequate for a variety of reasons. The Global Self-consistent, Hierarchical, High-resolution Shoreline (GSHHS) dataset is in the public domain and has been a standard resource for years, but is now over 20 years old and was originally derived from nautical charts (Wessel and Smith 1996). We required a more current and image-derived representation of the global shoreline for our ECU mapping initiative. Both 30 m image-derived and 16 m DEM-derived coastlines are available from private sector sources, but their proprietary nature precluded their consideration for use in the ECU effort. Finally, there is an increasingly complete Open Street Map® (OSM) global shoreline product which is freely available in the public domain (http://openstreetmapdata.com/data/coastlines), but its development as a crowd-sourced resource was flagged as a concern in terms of standardisation and replicability. A decision was therefore made to develop a new global coastline which would represent the spatial backbone and initial source of linework for the ECU development.

In their review of shoreline definition and detection techniques, Boak and Turner (2005) described three methods for delineating coastlines: 1) interpretive capture of a discernible feature such as mean high water line in imagery or from field survey, 2) intersection of a tidal datum with a coastal profile, and 3) derivation by spectral analysis of remotely sensed imagery to separate land and water features. The GSV is an example of the third approach, produced from a semi-automated supervised classification of imagery. As such, the GSV represents an instantaneous shoreline, the position of the shoreline at an instant in time (Boak and Turner 2005). Analysis of changes in the position of the instantaneous shorelines interpreted from a time series of Landsat images have successfully documented coastal erosion and accretion (Kalaranjini and Ramakrishnan 2016), and image-derived instantaneous shorelines have been used as the pre-cursor for development of tide-coordinated mean high water shorelines (Dang et al. 2018).

Method

Cloud-based classification of imagery

The GSV was derived from a dynamic, semi-automated classification of 2014 Landsat 7 satellite images. The classification was conducted in the Google Earth Engine (https://developers.google.com/earth-engine/classification) environment to facilitate the on-line processing of hundreds of images. The extraction was accomplished by 'running' the entire global coastline using an algorithm to obtain a two class (water, land) separation on every Landsat image that contained a coastline. The cloud-based supervised classification of 30 m imagery was conducted primarily on top of atmosphere (TOA) annual composites of Landsat scenes from 2014 from the Google Earth Engine data archive (https://earthengine.google.com/datasets/). Occasionally, three year composites (2012–2014) were used if the 2014 annual composite still showed significant coastal zone cloud contamination on visual inspection. The composites represent the median pixel reflectance from all the images in the target period (2014 for single year composites, 2012–2014 for the three year composites). Using composite imagery improved feature detection by minimising obstruction from clouds, but precluded the delineation of a high water line because tidal control could not be incorporated. The resulting vector therefore characterises a coastline position somewhere between the high water line and the low water line (the shore zone) and is therefore called a shoreline vector.

A single analyst executed the entire semi-automated classification, first tiling the planet into 10° by 10° grid cells, and then classifying all coastline-containing images in each cell. The analyst dynamically classified the coastline by proceeding along it while identifying a number of training points representing the range of reflectance from a variety of types of land (vegetated, non-vegetated, etc.) and water (deep, shallow, etc.). Training data were interactively collected using the geometry drawing tools. The training points were used to classify the imagery into a two class separation (land and water). The Naïve Bayes classifier was selected for its known minimisation of average risk of classification error and robust characterisation with relatively smaller numbers of training points (Park 2016). The classification was dynamic in the sense that the layer was re-created on-the-fly after any change in the mapextent of the viewer, including any pan or zoom. Classifications were run and rerun in each of the 220 tiles until the user and producer errors were in the 95% or better confidence level. This was a very dynamic process, which included adding more points as necessary to bolster the statistical confidence. As such, a different number of points were used for each tile. While very expedient, the dynamic and progressive-adjustment nature of the algorithm did not provide for retention of the training points or confusion matrices. As an approximation of the sampling intensity, it is estimated that about 40,000 points across 220 tiles were used to train the classification.

Post-classification data manipulation

The classified raster was then brought down from the cloud in GeoTIFF format for post-classification processing in industry standard GIS software (ArcGIS® and ERDAS Imagine®). Initial raster smoothing was accomplished using a 3 × 3-neighborhood majority filter, followed by identification of groups of contiguous land pixels (clumps). An eliminate command was used to remove clumps with fewer than four contiguous pixels, establishing 3600 m^2 (0.036 km^2) as the effective minimum mapping unit (MMU) for the analysis. As such, any island <0.036 km^2 was not mapped. A raster to vector conversion yielded 30 m spatial resolution coastlines for continental mainlands and all islands greater than the MMU, and these vectors were subsequently generalised using the PAEK algorithm (Bodansky et al. 2001) to smooth the stairstep effect of vectors produced from raster edges. The vectors resulting from the classification output were connected line segments which lacked polygon topology. The data were therefore manually cleaned to fix any errors associated with missing segments, artifacts like dangling nodes, and duplicate coincident segments. Polygon topology was then established, in essence creating a new global islands database. Three layers were then developed from the all polygons file; continental mainlands, islands >1 km^2, and islands <1 km^2.

Results

Shoreline was mapped for a total of 340,691 landmasses, five of which are continental mainlands, 21,818 of which are islands greater than 1 km^2, and the remaining 318,868 of which are smaller than 1 km^2 (Table 1). The global GSV is depicted in Figure 1, and its distribution along the Florida Keys in the United States is depicted in Figure 2. A visual comparison of the GSV and the Global Self-consistent, Hierarchical, High-resolution Shoreline (GSHHS; Wessel and Smith 1996) is presented in Figure 3. The smaller islands (< 1 km^2) are generally not visible when viewing the data on a computer in a global mapextent (Figure 1). These smaller landmasses appear in view when zoomed in to a mapextent of about 1:1,000,000, the display scale shown in Figure 2.

Table 1. A characterisation of the global occurrences of landmasses from an analysis of a 30 m spatial resolution, 2014 Landsat imagery-derived global shoreline vector (GSV).

Landmass type	Number of polygons	Area (km^2)	Length of coastline (km)
Continental mainlands	5	125,129,046	813,467
Islands > 1 km^2	21,818	9,938,964	1,304,762
Islands ≤ 1 km^2	318,868	20,589	321,774

The new global shoreline vector (GSV) product improves on the accuracy and spatial resolution of existing non-commercial global shoreline datasets (e.g. see Figure 3).

Discussion

The new shoreline vector, although derived from an annual image composite which ‘averages’ the coastline position over twelve months, is still regarded as an instantaneous position, and is not tidally corrected. In areas like mudflats where tidal fluctuation is considerable, the coastline position at the time of satellite image acquisition may be quite distant from, for example, the high water line. Moreover, the 30 m spatial resolution of the Landsat imagery, while a relatively fine spatial resolution for a global product, may be considered relatively coarse when contemplating a local coastline. Many areas of the planet have coastlines mapped at finer resolutions than 30 m, and a Landsat image-derived coastline position would hardly be considered suitable for navigation. Caution is therefore always advised when contemplating using the GSV for local applications. The new 30 m GSV product has both fitness-for-purpose and fitness-for-scale dimensions, and it should be evaluated for these potential utilities prior to use.

Using the GSV in a time series to characterise, for example, change in coastal geomorphology, must also be carefully considered. The GSV is not a baseline (e.g. long-term average) position against which change can be assessed. It is a 2014 average instantaneous coastline position, and could be compared with instantaneous shorelines derived in the same way from other years. However, year-to-year changes in coastline position should probably be assessed using tidally-corrected data (Dang et al. 2018).

Although the GSV data were developed as an input to the ECU modelling, they also represent a rich new

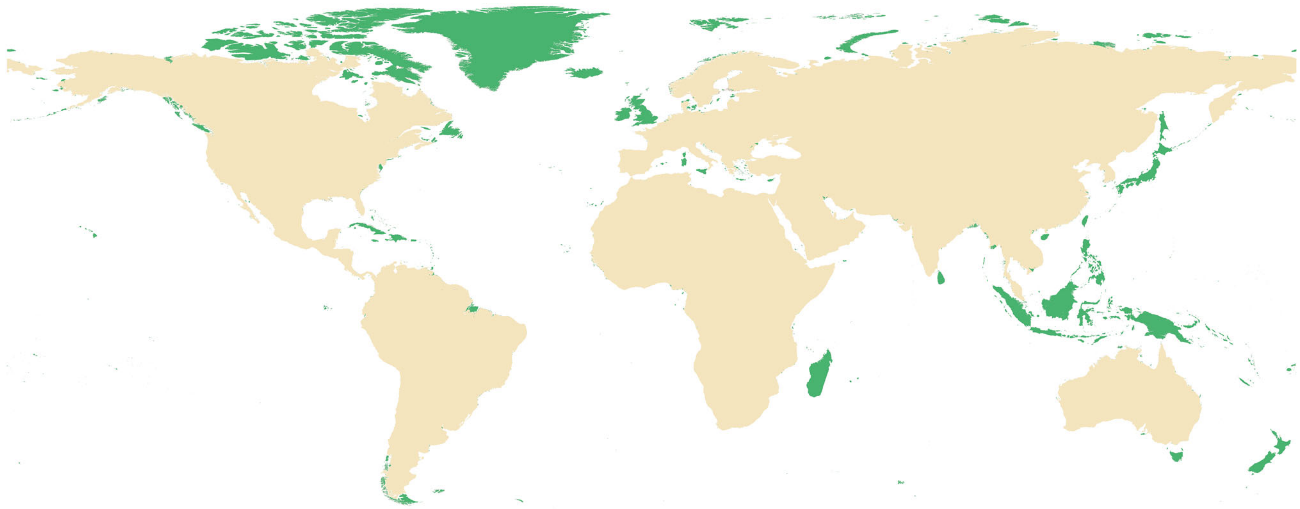

Figure 1. A new, high spatial resolution (30 m), standardised global shoreline vector (GSV) derived from 2014 Landsat annual composite imagery. The continental mainlands are shown in tan, and islands greater than 1 km^2 in area are shown in green. Islands smaller than 1 km^2 are too small to be seen at this display scale.

database on global islands, and a number of analyses are possible which consider the data more in an islands, rather than shoreline, context. The GSV linework is complete, and attribution to add a Name field is underway. Future work is needed to attribute names to all continental mainlands and islands > 1 km^2 using a combination of geographic names resources, Google Maps®, Esri's World Topographic Basemap®, etc. Attempts to name the more than 300,000 islands that are < 1 km^2 are not anticipated given the sheer immensity of that effort, and the fact that many of these landmasses probably represent nameless rocky outcrops.

The global islands data are available in the public domain as an open, no cost resource at https://rmgsc.cr.usgs.gov/ecosystems/datadownload.shtml. It is also anticipated that the GSV data will be made available in the Living Atlas® resource of ArcGIS Online (AGOL®).

Open access, spatially explicit global island databases with which to compare the GSV island numbers and sizes are lacking. Two versions of a polygon Global Island Database (GID) are described in a compendium of marine data and tools from the UNEP World Conservation Monitoring Center (Weatherdon et al. 2015). From the metadata descriptions, version 1.0 of the GID was derived from the GSHHS (Wessel and Smith 1996) data and contains approximately 180,000 islands. Version 2.1 of the GID represents an update of version 1.0 based on the use of the OSM shoreline product, and contains approximately 460,000 islands. The GID version 2.1 is still in development, as is the GSV, but a future comparison of the resolution, accuracy, and completeness of these two resources for both global shoreline and island assessments is encouraged.

Next Steps – proposed ECU modeling approach

Having developed the GSV as the intended spatial foundation for developing ECUs, an anticipated next step might be to undertake testing of its fitness for that purpose, and the extent to which it can be exploited. The GSV is a very rich resource, and it may not be practical to attempt to model ECUs on every segment of coastline that it contains. Preliminarily, plans include the development of ECUs along the five continental mainlands and for the 21,818 islands > 1 km^2. In general, a two step process to model the ECUs is envisioned, building from and incorporating the GSV as the spatial framework for future line work development. The proposed work described below is intended to describe potential logical and practical next steps, but feedback on the approach and participation from the coastal ecosystem mapping community is invited.

Step one – define the boundaries of three ecological subzones

Having established the GSV as the land/water interface separating the terrestrial from the aquatic domains, the next step would be to delineate three ecological subzones (coastal land areas, nearshore aquatic waters, offshore aquatic waters) comprising the global coastal zone. The coastal land areas subzone would extend inland from the GSV to either a fixed distance, or a geomorphic boundary that represents the separation of coastal from non-coastal regions. A fixed distance (10 km) buffer bounding the inland extent of the coastal zone has

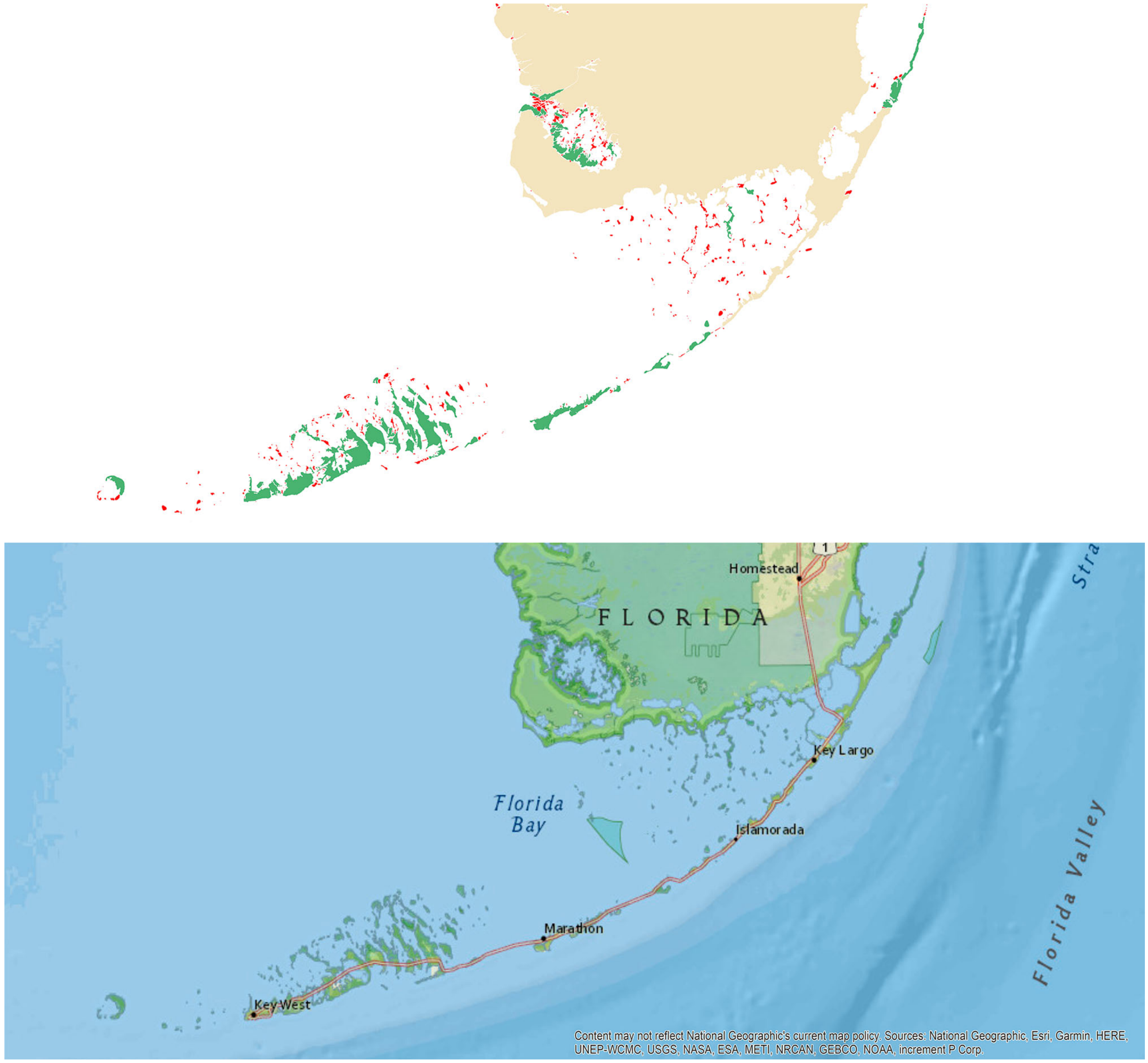

Figure 2. Top – The GSV along the Florida keys in the United States. The continental mainland of North America is shown in tan, islands > 1 km^2 in area are shown in green, and islands < 1 km^2 are shown in red. These landmasses are depicted at a 1:1,000,000 scale. Bottom – For cartographic reference, the same area of the Florida Keys (source: National Geographic Basemap® as included in ArcGIS®) is depicted at the same scale (1:1,000,000).

been identified as the integrated coastal zone management (ICZM) standard for biodiversity and climate change studies in European Union nations (Lavalle et al. 2011). A fixed coastline buffer is a simple and practical limit for identifying inland extent of coastal land areas, and will be evaluated for potential use in the ECU mapping effort. Alternatively, the use of a geomorphic feature, such as the limit of a global coastal plains landform produced from terrain characteristics, will also be evaluated for use. A terrain-based global landforms layer (Karagulle et al. 2017) derived from a 250 m digital elevation model (Danielson and Gesch 2011) identifies 16 classes of landforms (four mountain classes, four tablelands classes, four hills classes, and four plains classes). This global landforms layer could be used to produce a global coastal plains layer, which would represent the occurrence of coastal plains features that intersect with the GSV and are bounded inland by hills and mountains. As coastal plains can extend inlands hundreds of kilometres from the coastline, a maximum distance would need to be established to limit the inland extent. Where cliffs, mountains and hills directly abut the coastline, the inland extent of the coastal land area could be extended in from the GSV to a fixed distance that would ensure inclusion of rookeries and similar features considered as important habitat for coastal biodiversity.

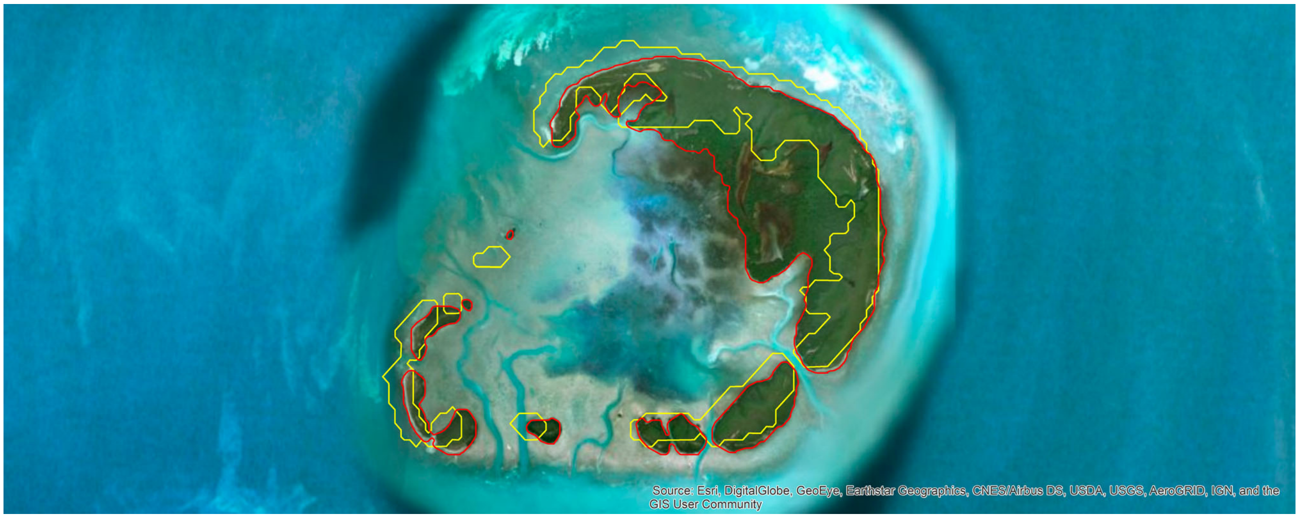

Figure 3. A visual comparison of the GSV and the GSHHS (Wessel and Smith 1996) for an archipelago at the westernmost end of the Florida Keys, United States. The underlying image is from a 1:65,000 level zoom of Esri's World Image Basemap. The yellow lines represent shorelines from the GSHHS, and the red lines depict GSV shorelines. Only the largest polygon shown is > 1 km^2. The GSV shows improvement in the visual fit of the coastline vectors to the shore.

On the seaward side of the GSV, coastal waters could be mapped out to the edge of the continental shelf, as previously mapped by Harris et al. (2014). The continental shelf is a physiographic province recognised in numerous biogeographic and habitat classification schemes as ecologically distinct, both in the pelagic (neritic) waters above it, and its seabed (benthic) environments (Harris 2012; Populus et al. 2017). A 200 m depth could be evaluated as an alternative, ecologically meaningful seaward mapping boundary in cases where the shelf extends beyond a 200 m depth. An analysis of the global EMUs (Costello and Breyer 2017) documented a separation of the epipelagic (photic) zone from a mesopelagic (twilight) zone at a depth of 200 m. Continental shelf waters could then be separated into nearshore and offshore at a depth of 30 m according to the Coastal and Marine Ecosystem Classification Standard of the United States (CMECS; FGDC 2012) or at a yet to be determined level of significant attenuation of light (Populus et al. 2017), depending on availability of globally comprehensive turbidity data. Nearshore waters are the zone where wave energy interacts with the seabed to influence sediment motion and turbidity, and the seabed and water column environments are tightly coupled, creating an ecologically distinct zone from the offshore waters where wave and current action is less conspicuous (FGDC 2012).

Step two – delineate ECUs within each of the three subzones

ECUs could then be mapped as distinct combinations of physical environment and matrix-forming biological assemblages. For coastal waters, the biological assemblages could include mangroves, salt marshes, coral reefs, seagrasses, kelp forests, and shellfish beds, to the extent that globally comprehensive data for these systems are available (e.g. the emerging Ocean+ Habitat Atlas in development at the World Conservation Monitoring Center). For coastal lands, the biological assemblages could be represented by land cover types aggregated to forests, shrublands, grasslands, croplands, and sparsely vegetated surfaces. For coastal land areas, the physical settings could be characterised using climate, landform, lithology, and other environmental datasets. The 250 m ELU data (Sayre et al. 2014) could be evaluated for utility as an existing characterisation of terrestrial physical setting. For coastal waters, the physical environment settings may include temperature, salinity, depth to seafloor, dissolved oxygen, nutrient levels, turbidity, etc., again based on the availability of globally comprehensive data (e.g. Basher et al. 2014). Sayre et al. (2017) included several of these variables in their development of global EMUs.

The descriptors used to characterise the coastal waters physical environment settings would likely include tectonic, geomorphological, and hydrodynamics variables, and will emphasise analysis of tidal, fluvial, and wave regimes to identify depositional and erosional environments following on approaches outlined by Harris et al. (2002) and Nyberg and Howell (2016). For any of the variables under consideration, availability of globally comprehensive data at a sufficiently fine spatial resolution will determine initial feasibility for use in the analysis.

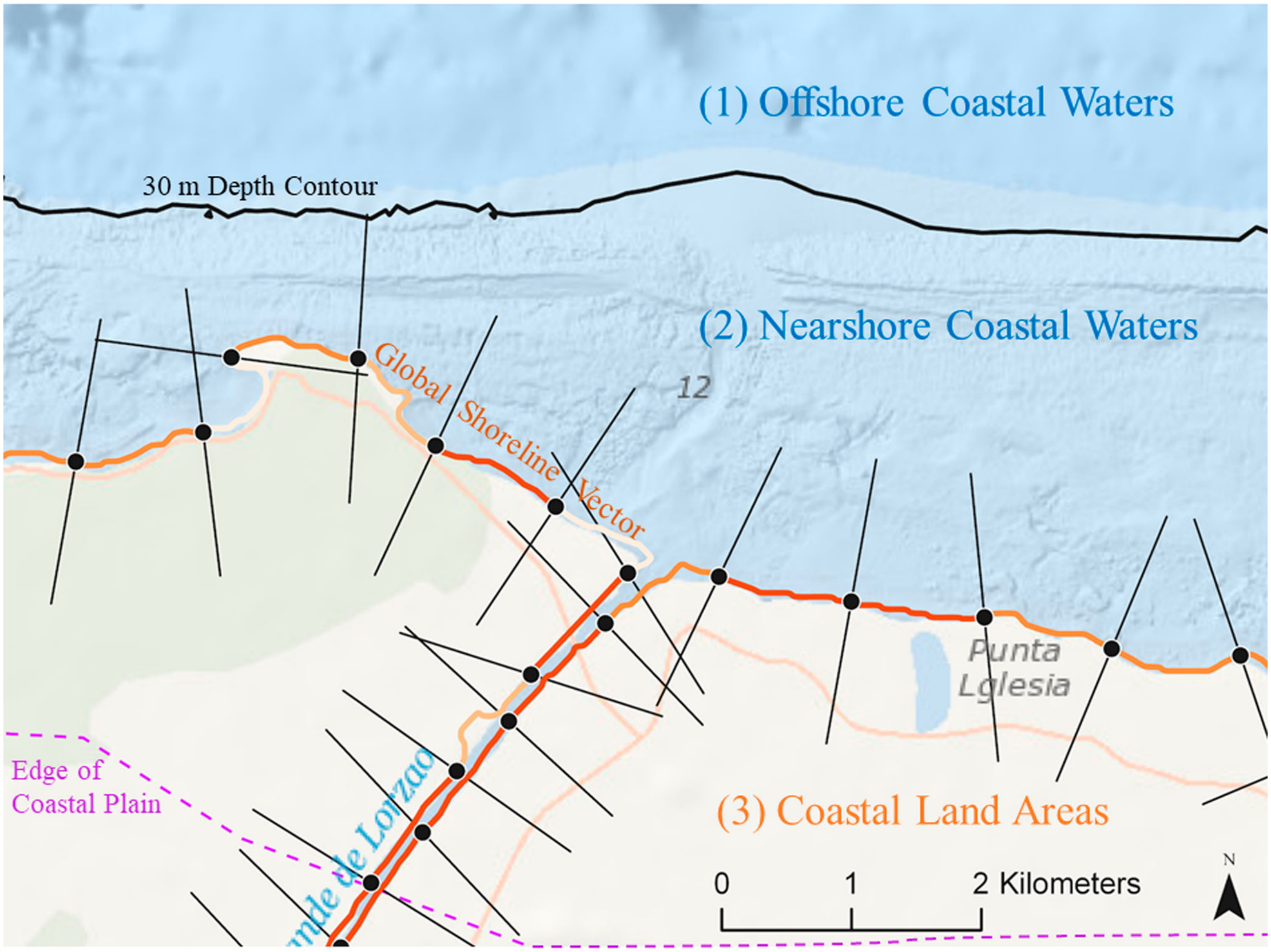

Figure 4. Illustrative example of the ecological coastal units (ECUs) spatial analytical framework showing the new Global Shoreline Vector (GSV) along a stretch of coast in northeastern Puerto Rico. The GSV is shown with regularly spaced segments attributed and symbolised, in this case, by sinuosity. Perpendicular transects placed at segment intervals are also shown. The segments and transects represent potential spatial objects which could be attributed with data and used to delineate ECUs. The proposed ecological zonation is also shown, including offshore (a) and nearshore (b) coastal waters separated by the 30 m depth contour, and coastal land areas (c) between the GSV and the inland limit of the coastal plain.

The analysis would be based on statistical clustering of point data representing longest possible temporal averages in an effort to target historical average conditions. Existing globally comprehensive point data could be interpolated to perpendicular transects or rectangular areas placed along the global shoreline vector at all river mouths, and then at a fixed spacing between river mouths to the extent possible, and at a distance which is fine enough to capture physical environment variation, yet coarse enough to be manageable in a data analysis sense. The exact spatial analytical unit and clustering approach would be identified following evaluation of alternatives such as simple segmentation and attribution of the GSV, use of transects or rectangular compartments centred on the GSV, use of hexagons or similar that completely tessellate the three ecological zones, etc. An illustrative graphic depicting the three ecological zones, and two spatial objects (coastline segments and perpendicular transects) which could be used for ECU delineation is presented in Figure 4. Whatever the approach, available data could be used in a global k-means clustering to geographically separate areas of relatively homogenous physical environment/biological assemblage combinations. Variation in the decline of the pseudo-F statistic could be assessed to identify candidate optimal cluster numbers for the global ECUs as demonstrated in the global clustering of marine physical environment data by Sayre et al. (2017).

The Blue Planet initiative of the Group on Earth Observations

GEO's Oceans and Society – Blue Planet initiative (https://geoblueplanet.org/) seeks to support activities focused on sustainable development, including sustainable coasts, maritime safety, marine biodiversity and ecosystems, and ocean resources. The GSV and the ECUs which will be developed from it are likely to be of interest to a wide range of individuals and organizations in the GEO Blue Planet network. Coastal communities anywhere on the planet will have open and free access to accurate and high spatial resolution data on coastal land and coastal aquatic ecosystems in and near their jurisdictions. Community assessments of ecosystem health and ecosystem services generation (e.g. food provisioning) will require local and regional knowledge and maps of ecosystem distributions on land and in the sea. Even though the GSV and the ECUs are a global resource, their high spatial resolution may be suitable for place-based applications. The ECUs will likely be useful for assessments of blue carbon stocks and flows as well given that they will include distribution information on carbon sequestering biological assemblages like salt marshes, mangroves, seagrasses, and kelp forests. Finally, the ECUs and the GSV will represent a new wealth of ecosystem and environmental information for marine spatial planning and maritime awareness.

Conclusion

A new global shoreline resource was developed to underpin a commissioned and planned characterisation of global ecological coastal units. The GSV is a rigorous, 30 m spatial resolution, vector-based depiction of shorelines and islands, and was derived from classification of 2014 Landsat images. The GSV is available in the public domain as a standardised, semi-automated, high resolution coastline, and represents an alternative to both commercial and crowd-sourced coastline resources. The GSV is intended to be useful for a variety of programmes (e.g. GEO's MBON and Blue Planet) which address coastal and marine biodiversity conservation, natural resource management, assessment of 'blue' carbon, and economic and non-economic valuation of coastal ecosystem goods and services. The GSV can be used to delineate standardised, robust, global ecological coastal units which are intended to be useful for a variety of research and management applications.

Acknowledgements

The authors are grateful for helpful reviews from Lisamarie Windham-Myers of the U.S. Geological Survey and two anonymous referees. Ms Sharon Hamann passed away during the preparation of this manuscript. She worked tirelessly and meticulously on the new global shoreline vector, and will be missed. Any use of trade, product, or firm names does not imply endorsement by the US government.

Disclosure statement

No potential conflict of interest was reported by the authors.

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