Mapping of Albania's inshore waters for supporting suitable loggerhead nesting beaches

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Introduction

Sea turtles' lives are shaped by environmental temperatures, which ultimately define their global distribution. Having an ancestry lineage that stretches over millions of years, sea turtles' distributions will have expanded and retracted to adapt with global climatic changes. The presence of loggerhead turtles (*Caretta caretta*) in the Mediterranean derive from the Atlantic populations (Bowen et al. 1993) and they are estimated to have entered the Mediterranean approximately 65,000 years ago, prior to the last Glacial Maximum of the Pleistocene era (Clusa et al. 2013). At the time when most of the Mediterranean would have been too cold to support sea turtles, it is proposed that the southern Mediterranean waters provided a warm sanctuary for the loggerhead population. This hypothesis is supported by an mtDNA study of several Mediterranean rookeries, identifying Libya's rookery as having the oldest lineage *circa* 65k years ago, followed by Turkey and Greece *circa* 30k years ago (Clusa et al. 2013). As global temperatures rose, loggerhead turtles dispersed into new suitable habitats as they became available.

At present two species of sea turtles breed within the Mediterranean Basin, the loggerhead, with major rookeries located across the central and eastern basin and the green turtle (*Chelonia mydas*), with nesting activity restricted to the eastern basin (Casale et al. 2020). In addition to these established nesting sites, sporadic sea turtle nests are laid outside the 'normal range' and have been recorded in Spain (Tomás et al. 2002), France (Delaugerre &

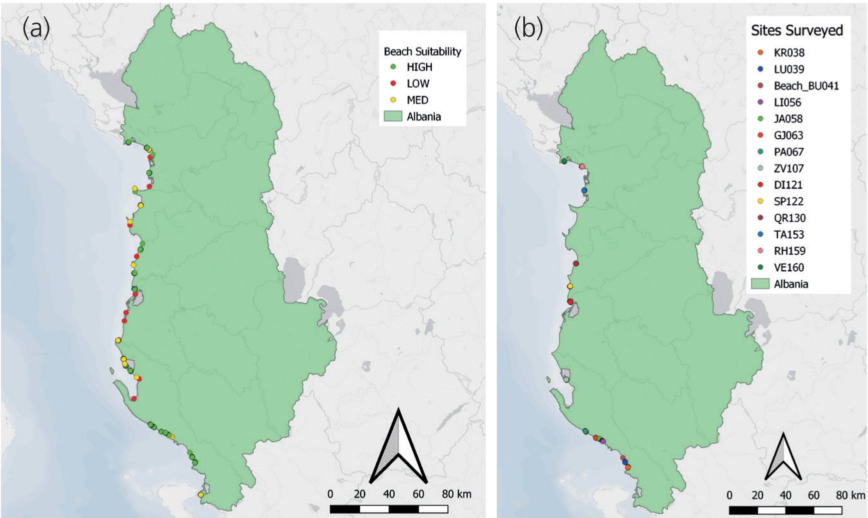

Fig. 1. Maps of Albania showing (a) beach suitability assessment 2018-2019 and (b) marine environment surveys 2019.

Cesarini 2004), Algeria (Benabdi & Belmahi 2020) and in Italy (Bentivegna et al. 2010). To date, they have primarily been attributed to loggerhead turtles and it is uncertain what the drivers for sporadic nesting events are; whether they have always been occurring but never officially recorded (Bentivegna et al. 2010) or are an indicator of modern-day climate change, driving sea turtles' dispersal into new suitable habitats (Carreras et al. 2018).

Loggerhead turtles were officially recorded in the Albanian marine environment in 1979 (Haxhiu 1979), with subsequent research confirming these inshore waters to be an important area for overwintering adults and developing juveniles (Haxhiu 1985, 1995; Haxhiu & Rumano 2005; White et al. 2008; White et al. 2011; Sacdanaku & Haxhiu 2012, 2013, 2015). The first official loggerhead nest was recorded in 2018 in the central region of Albania, Divjaka (Piroli & Haxhiu 2020), approximately 370km north the major nesting sites located along the Greek Ionian coastline. Previous accounts of nesting existed but were only available as anecdotal accounts and photo evidence of hatchlings on the beach. Under a MAVA Foundation funded programme, MEDASSET conducted a beach suitability assessment (2018 – 2019) along Albania's 427km coastline for its ability to support sea turtle nesting. Data collected evaluated the beach attributes of suitability for sediment type, elevation, compaction, and anthropogenic impacts. Of the 57 locations assessed, 20 were ranked as high, 25 medium and 12 low suitability, with the regions of Lezhe in the north and Vlore in the south presenting the highest densities of suitable beaches (Fig. 1) (Sacdanaku & Rae 2020).

Fig. 2a. Livadh (L1056): flight path survey area in DroneDeploy.

In identifying potential suitable sea turtle nesting beaches, it is also important to consider the adjacent marine environment for the inshore approach to the beach, for the seabed habitats, and the levels of disturbance and threats (Shanker et al. 2003; Cousins et al. 2017). Some previous research of inshore habitats from established loggerhead nesting sites have found a positive correlation for the presence of subtidal reefs in the approach to the nesting beach (Hughes 1974). For anthropogenic impacts, sites which have man-made structures may restrict female emergences to parts of the beach (Lamont et al. 2014), and present in-water threats of marine debris, fishing activity, and marine traffic (Kaska et al. 2013), which pose risks of entanglement, ingestion and collision to breeding adults.

Additional funding provided by the BCG enabled the expansion of the survey for the inshore marine environment for the potential nesting beaches. The objectives of this study were to (1) identify and map the inshore marine habitats of the approach, with a particular focus for subtidal reefs to identify potential beach preference, (2) assess the anthropogenic activity/impacts of the marine environment and (3) review the imagery for the presence of sea turtles within the inshore waters.

Fig. 2b. Livadh (L1056): spatial mapping of georeferenced images in QGIS of seabed habitats and anthropogenic activity (on-going analysis).

Methods

We used a DJI Phantom 4 Pro drone to carry out flights following a preplanned route programmed in DroneDeploy for mapping which collected imagery with a 75% front overlap and a 65% side overlap. The drone was set to fly at 3m/s, at an altitude of 30m, and was flown at 16 locations of the nearshore habitat up to 400m from the coastline. (e.g. Fig. 2a: DroneDeploy Flight path for Livadh LI056). Initially the images were uploaded into DroneDeploy to create maps of the surveyed area, but due to the homology of some of the mapped areas, the images were unable to be stitched together. Therefore, spatial analysis of the images was completed manually using ImageJ software, to calculate the extent of seabed habitats and the occurrence of anthropogenic activities. The Grid tool, comprising 63 squares, was overlaid on each image, and the percentage coverage calculated by the observer for the presence of each category identified in each of the grid squares, per image (X/63 x 100). The sum of all the images per survey was used to calculate the total coverage of the presence of each category identified for the survey area.

Spatial mapping is also being created in QGIS v3.10, uploading the georeferenced images and attribute data of the habitat types and anthropogenic activities for each surveyed site for future use (e.g. Fig. 2b).

Table 1. Results of image analysis in ImageJ using the Grid tool to calculate percentage coverage for each surveyed area. T_SqGRID is the total number of squares (63 per image) for the surveyed area. Sum of the presence of each category is presented under the specific heading, with the percentage coverage in the adjacent column.

SITES	T_SqGRID	SEABED HABITAT (excluding fine sediments)				ANTHROPOGENIC ACTIVITY/PRESENCE											
		Reef	%	Cobble/ Rubble	%	Fishing	%	Boating	%	Floating Platform	%	Mooring Line	%	Litter	%	Pier	%
KR038	26287	2504	9.5	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
LU039	26815	4978	18.6	0	0.0	0	0.0	25	0.1	0	0.0	4	0.0	10	0.0	0	0.0
BU041	25515	9771	38.3	0	0.0	202	0.8	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
LI056	40700	18346	45.1	4070	10.0	0	0.0	47	0.1	0	0.0	731	1.8	20	0.1	0	0.0
JA058	22026	12038	54.7	0	0.0	0	0.0	117	0.5	26	0.1	847	3.9	0	0.0	0	0.0
GJ063	17789	2823	15.9	0	0.0	0	0.0	23	0.1	0	0.0	0	0.0	0	0.0	0	0.0
PA067	31993	4728	14.8	9018	28.2	0	0.0	0	0.0	0	0.0	379	1.2	0	0.0	0	0.0
ZV107	27080	5783	21.4	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
DI121						0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
SP122	43438	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	39	0.1	0	0.0
QR130	14742	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	15	0.1	67	0.5
TA153	36671	211	0.6	493	1.3	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	00	0.0
RH159	30877	35	0.1	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
VE160	33453	0	0.0	0	0.0	0	0.0	11	0.0	0	0.0	100	0.3	0	0.0	0	0.0
TOTALS	377386	61217	16.2	13581	3.6	202	0.1	223	0.1	26	0.0	2061	0.6	84	0.0	67	0.0

Results

Aerial surveying, in the marine environment adjacent to 16 locations assessed to be highly suitable (Fig. 1), resulted in 9,229 images collected during 2nd July to 29th September 2019 (Table 1). Two sites DRY066 and DA108 were excluded from analysis due to poor image quality, and no inshore habitat analysis could be performed for DI121 due to the extremely high turbidity of the water. No sea turtles were observed in the drone images.

Seabed habitats: three broad seabed habitat types were identified in the inshore environment: fine sediments (sandy or muddy sand), subtidal reef or cobble/rubble (Fig. 3). Fine sediments were the most commonly exhibited habitat type within the inshore approach (80.2%), followed by rocky reefs (16.2%) and then cobble/rubble (3.6%) (Fig. 4). With the exception of some small rocky outcrops present in TA153 and RH159, hard substrata habitats (rocky reefs and cobble/rubble) were only present in the approaches of the southern beaches (Fig. 5). All these locations, except ZV107, are situated within the Ionian Sea.

Anthropogenic impacts: six anthropogenic activities and modifications were identified throughout the imagery – fishing activity (deployed static net), recreational boats (travelling and anchored), temporary floating platforms, jetty infrastructures, marine litter and mooring lines which were used as anchor points and zonation for tourist activity.

Tourist related activities of recreational boating and the presence of mooring lines were the most commonly recorded across the sites (35.7%; n = 5), with mooring lines covering the greatest spatial expanse as recorded per grid square (Fig. 6). Four locations did not record any form of anthropogenic impacts within the surveyed marine area. Two of these locations also did not have any form of anthropogenic activity from the beach assessment survey, which was most likely to be due to reduced accessibility at KR038 and to DI121 being part of a National Park.

Discussion

Previous studies from around the world of major sea turtle nesting sites have found correlations between the nest site selection and the offshore approach presence of subtidal reefs in the offshore approach to the beach (Mortimer 1982); for loggerhead species the presence of subtidal reefs has been recorded as a positive association in nest site selection (Hughes 1974). From the imagery collected in this study, the offshore approaches that exhibit subtidal reefs off the 'highly' suitable beaches are located along the Ionian coast in the south. However, despite suitable parameters for nesting exhibited in beaches along the entire Albanian coastline, to date loggerhead sporadic

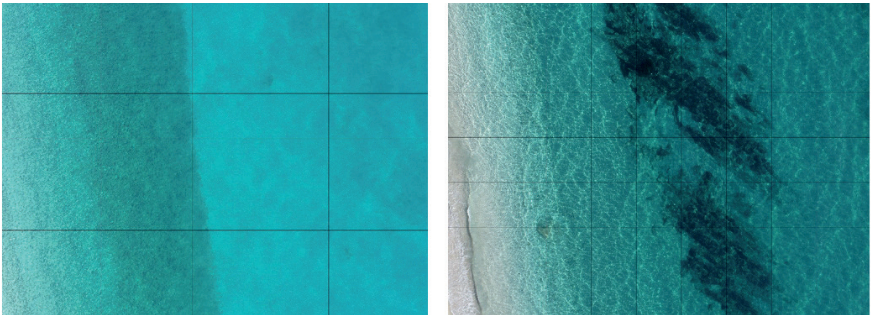

Fig. 3. Drone Images analysed in imageJ displaying Cobble/Rubble habitat (left) and Reef habitat (right).

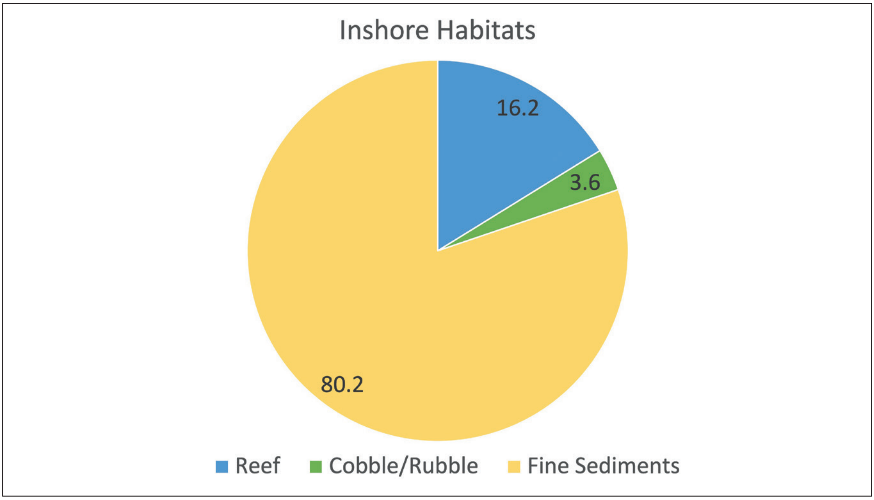

Fig. 4. Total percentages of spatial seabed habitats recorded for inshore approaches of potential nesting beaches.

nesting has only been recorded along the northern Adriatic coastline, which from the beaches surveyed in this study, exhibit predominantly sandy offshore approaches (Fig. 1). There is however a potential advantage for hatchling survival. The absence of subtidal reefs in the northern region suggest a lower risk of predation as the complexity of habitats of the southern inshore waters support higher biodiversity (Miho et al. 2013), which in turn suggests a higher number of predators may be present (Gyuris 1994).

This apparent preference for nesting in the northern region is most likely to be influenced by a larger spatial offshore physical characteristic of the marine environment, instigated by the width of the continental shelf. In the northern Adriatic region, the offshore extent of the continental shelf is much

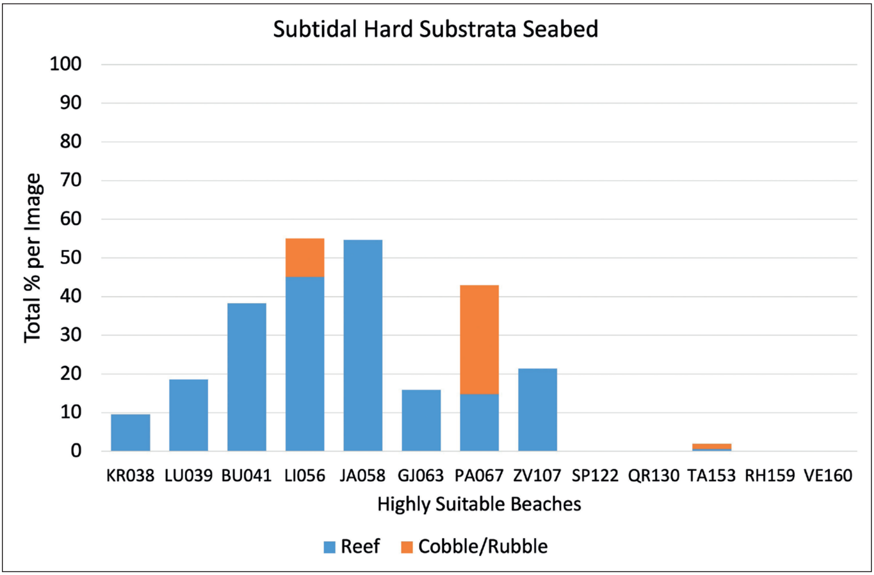

Fig. 5. Percentage coverage of seabed habitats along the Albanian coastline of surveyed sites. Sites are presented as south to north, left to right on axis.

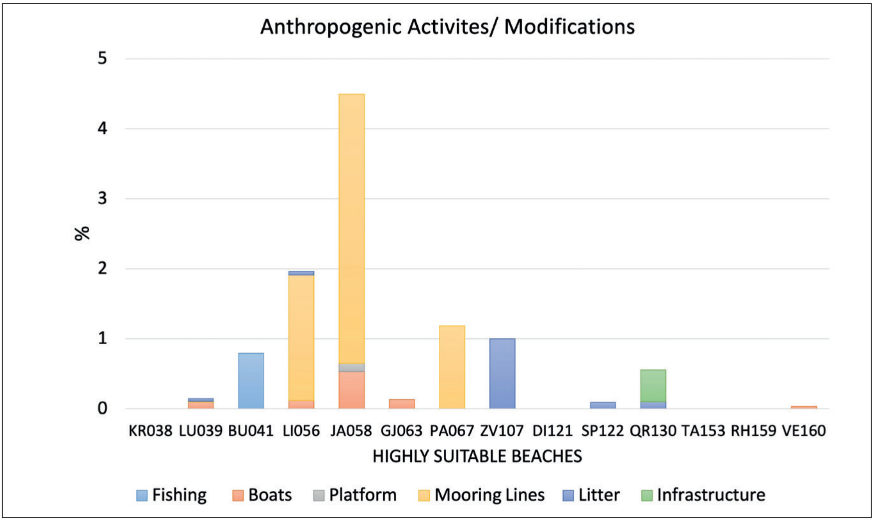

Fig. 6. Percentage coverage of anthropogenic activities along the Albanian coastline of surveyed sites. Sites are presented as south to north, left to right on axis.

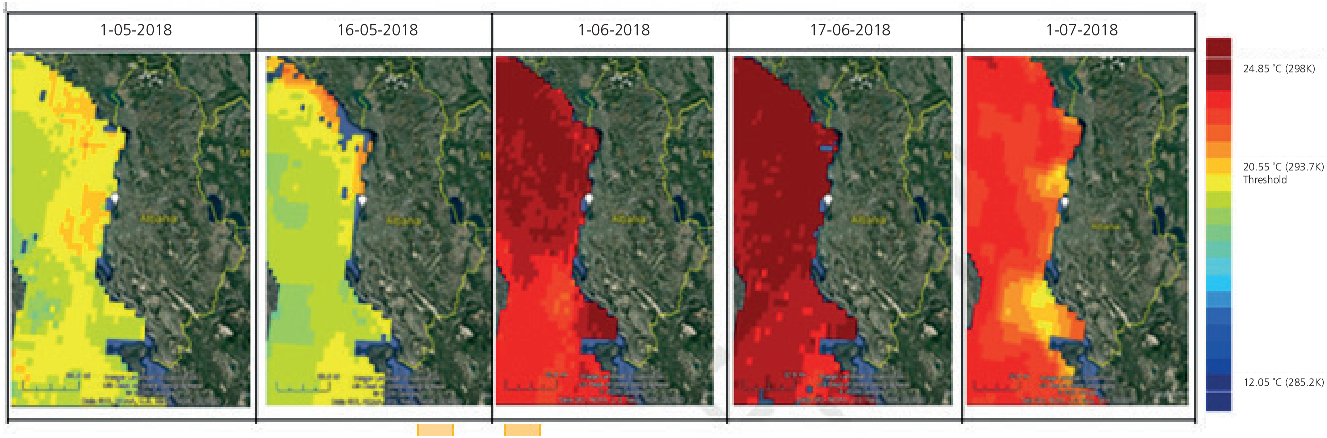

Fig. 7. Sea surface temperature maps generated using E.U. Copernicus data (Copernicus Ocean Monitoring Indicators 2018); dataset 'Mediterranean, SST, L3S, 1/16deg daily. The location of the 2018 nest (DI121) is indicated by the white dot.

wider than in the southern Ionian region, providing a larger area of shallower waters and in turn warmer seawater temperatures. Reviewing the 2018 sea surface temperature satellite data (Copernicus Ocean Monitoring Indicators 2018), shows that the entire coastline of Albania's inshore waters pass the temperature threshold of 20˚C to support the in-water maturation of eggs in females (Márquez 1990) and promote nesting activity. However, these temperatures are attained earlier during the nesting season (May/June) than in the deeper waters of the southern region (Fig. 7) and potentially provide a stronger influence for nest site selection along the northern coastline. Unfortunately, the image data collected for the inshore approach of the nest laid at Divjaka could not be analysed for seabed habitats due to extreme low visibility of the water column and it is unknown if any subtidal reefs are present there.

One of the largest anthropogenic threats to sea turtles' nesting sites is conflicts with tourism. Albania is rapidly developing its coastline to accommodate a growing tourism industry (Foreign tourist arrivals 3,415,550 – 6,094,889 between 2014 and 2019; Institute of Statistics, 2020). One of the main activities recorded in the inshore waters to the potential suitable beaches is the presence of boating activity; this poses a potential serious threat to any breeding adults with the risk of injury or death with boat strikes (Papafitsoros et al. 2020). Although preventative management measures such as zonation or the use of propeller guards exist, due to the temporal and spatial uncertainty of sea turtle nesting across Albania's coastline, pre-determining site-specific management measures is not yet feasible. However, as these threats have been identified, it does highlight the importance of including maritime assessments and evaluations with any future conservation considerations for future nesting events.

Over the last decade, there has been an increased interest in sporadic nesting events linked to concerns of how climate change might alter the current distribution of nesting and the sea turtles' ability to adjust to the present-day rates of change (Tomás et al. 2008). Although much research has been achieved for defining the different parameters of suitable nesting conditions for sea turtles, this research is derived from established nesting sites and their conclusions of preference vary (Türkozan et al. 2011), making it difficult to predict future nesting sites. Implementation of a monitoring programme for sporadic nesting activity in Albania, which includes the marine environment approach and beach parameters, provides an opportunity to increase our understanding of nest site selection and drivers of sporadic nesting, to identify future suitable nesting areas in our dynamic environment.

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