Developing Marine Spatial Planning (MSP) Tools for the Turks and Caicos Islands. DPLUS094

Workshop 2 September 29th & 30th and October 6th & 7th 2020

Developing methodologies for modelling/analyses to identify ecologically important areas for Marine Spatial Planning in the Turks and Caicos Islands

This report was prepared as part of the Darwin PLUS 094 project 'Developing Marine Spatial Planning (MSP) for the Turks and Caicos Islands' for all stakeholders and interested parties in the Turks and Caicos Islands and overseas.

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Introduction

Marine Spatial Planning (MSP) background

Like the rest of the world, human use of coastal and marine resources in the Turks and Caicos Islands (TCI) is placing growing and often conflicting demands on natural resources. Consequently, important marine areas are under increasing pressure that threatens the health of coral reefs, mangroves, and seagrass beds and the environmental services they provide, such as coastal protection from storms, fishing grounds, important areas, tourism and of course climate change.

Marine Spatial Planning (MSP) is a method of managing the human uses of the marine environment, as the name implies, MSP is spatial planning for the ocean and is defined as '*a public process of analysing and allocating the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic, and social objectives that usually have been specified through a political process*' (Ehler and Douvere 2009).

To achieve these objectives marine ecosystem components, including human society, pressures and impacts need to be considered, with the aim of maintaining marine ecosystems in a healthy, productive and resilient condition so that they can provide goods and services, and sustain human uses of the ocean. By combining governance and science MSP aims to identify the spatial distribution of human activities and ecosystems in the ocean, so that existing and emerging uses can be maintained, conflicts reduced, and ecosystem health and services protected and sustained into the future. The spatial component of MSP involves the collection and collation of multi-disciplinary data, in an accessible format and at multiple scales, from a number of sources. Using these data to identify important marine areas supports the TCI Constitution (2011) which states in section 18 that "*The government shall, in all their decisions, have due regard to the need to foster and protect an environment that is not harmful to the health or well-being of present and future generations, while promoting justifiable economic and social development.*"

TCI general background

The TCI is one of 14 United Kingdom Overseas Territories (UKOTs), a small island in the Caribbean that lies south-east of the Bahamas chain, 145 km north of Hispaniola (Haiti and the Dominican Republic) and 925 km south-east of Miami (Figure 1). The easterly occurring Turks Islands are separated from the Caicos Islands by a deep-water channel approximately 35km wide. TCI is relatively flat. Providenciales rises to a high point of 50 m above sea level and Flamingo Hill on the North Western point of East Caicos has an altitude of also approximately 50 m. Sinkholes, caves and ridge formations are common. The islands consist largely of Pleistocene oolitic limestone and unconsolidated Holocene sands. The TCI population is 42,953 (2019), and the total area of the EEZ is 154,058 km^2. Tourism is the main contributor to the TCI economy, followed by the offshore financial sector, fishing for export to the US (mainly lobster and conch) is the third most important economic sector in the islands.

An overview of existing MSP in TCI

The Turks and Caicos Island Government (TCIG) has a number of departments e.g. DECR, Tourism, Ports, Police, that work in the Marine environment – some of whom have management and/or enforcement functions. In addition, non-governmental organisations and the private sector also undertake activities in the marine space However currently no overall strategic approach to the spatial planning of the marine environment. The

It is to their credit that TCIG have well-established Marine Protected Areas that were originally designated in the 1980;'s (Mitchell and Barborak 1991; Zuidema, Plate, and Dikou 2011). Marine parks were created to provide protection for the natural resources of the TCI and to provide management

of marine areas for the benefit of tourism, fishing and boating (Logan and Sealey 2013). The TCI now has 35 protected areas consisting 11 National Parks, 11 Nature Reserves, four Sanctuaries and nine Areas of Historical Interest, all declared under the TCI National Parks Ordinance (Figure 1, Table 1), 28 of which have a marine component.

DPLUS094 Project Background

The project 'Developing Marine Spatial Planning (MSP) Tools for the Turks and Caicos Islands' is a two-year project funded by the UK Department for Environment, Food & Rural Affairs (DEFRA) as part of the Darwin Plus program. The aim of the MSP project is to initiate the process of MSP by preparing data, tools and analyses, and by preparing a framework for MSP for the Turks and Caicos Islands. The results will inform the TCIG and its stakeholders on best practice and make recommendations for management and in developing a sustainable MSP.

The aim of the DPLUS094 MSP project is to:

> 1) develop an island wide metadata catalogue with a GIS database so that existing spatial and temporal data can be mapped and analysed to identify areas used by humans and wildlife, most important ecological areas, zones of conflict and any data gaps; and
> 2) create the framework and tools that will facilitate the implementation of MSP in TCI and legislation, which will feed into the long-term planning and decision-making.

The DPLUS094 project has a series of workshops built into the project delivery. The first 'Setting the Scene' workshops were held in January and February 2020, (South Caicos 27th January 2020, Grand Turk 31st January 2020 and Providenciales 4th and 5th February 2020) across TCI to initiate stakeholder dialogue.

Using WebGIS, a GIS database interface that works through a web browser, the spatial and temporal information on important areas and human uses of the marine environment, can be overlaid, analysed and used to identify overlaps between important areas and human uses of the marine environment.

Priorities from the previous workshops included identifying ecologically important areas and hot spots. For this workshop, and including the data we have collected and collated so far, we would like to discuss, explore and identify methodologies, data gaps and analyses that are the most appropriate to identify ecologically important areas and to develop an implementation plan to identify ecologically important areas for the TCI marine environment which will feed into the MSP process.

Ecologically Important areas

Ecologically important areas are spatially defined areas where aggregations of individuals of a species are known to display behaviours that facilitate survival, such as, but not limited to breeding, spawning, foraging, resting, nursing or migration.

- **Reproductive Areas**: Areas and months within which a particular species or population selectively mates, gives birth, or is found with neonates or other sensitive age classes.
- **Feeding Areas**: Areas and months within which a particular species or population selectively feeds. These may either be found consistently in space and time, or may be associated with ephemeral features that are less predictable but can be delineated and are generally located within a larger identifiable area.

- **Migratory Corridors**: Areas and months within which a substantial portion of a species or population is known to migrate; the corridor is typically delimited on one or both sides by land or ice.
- **Small and Resident Population**: Areas and months within which small and resident populations occupying a limited geographic extent exist

Ecologically important areas are identified using expert scientific knowledge and evidence about species' distribution, abundance and behaviour in a region. The presence of the observed behaviour is assumed to indicate that the habitat required for the behaviour is also present. The selection of species for which ecologically important areas have been identified is informed by the availability of scientific information, the conservation status of the species and the importance of the region for the species.

The process for identifying ecologically important areas involves mapping proposed areas digitally, based on expert advice and published literature.

The level of certainty attached to an important habitat has two dimensions:

- the certainty of the species' occurrence
- the certainty of the behaviour occurring.

There are two classes of presence: known to occur and likely to occur. The strongest certainty in an important area would be one where it is known that the species occurs in a particular area and it is known that the species displays a specific behaviour. A lesser certainty would be one in which the species is likely to occur in the area and is likely to display the behaviour.

A known important habitat is an area where the species is known to occur and includes areas where there have been confirmed sightings or robust records of the species exhibiting a biologically important behaviour in that area (i.e. sourced from observations or satellite tracking etc).

A potential ecologically important area is an area where the species is likely to exhibit a biologically important behaviour in that area. Potential ecologically important areas have been identified on the basis of extrapolations made by scientists:

- about suitable habitat that may support a biologically important behaviour that facilitates survival; and
- there is some evidence that the species is likely to be present in the area (e.g. strandings of dead animals on adjacent coastal areas or from fishing records, past observations).

Identifying relationships between behaviour and ecology is challenging as they vary over space and. Spatially, these relationships exist over distances varying from a few metres to thousands of kilometres and, temporally, over hours to months. Ecologically important areas may function as critical for population viability by providing optimal resources (e.g. shelter, food).

In addition to coping with environmental variations and resource availability within ecologically important areas, many animals must also cope with the consequences of human activities, including climate change. To quantify potential negative impacts of human activities on a species population, it is necessary to firstly identify ecologically important areas for population viability, which can be done by linking habitat characteristics and ecosystem processes to either species presence and/or important life functional behaviours.

Workshop series background

This MSP project is built around three main workshops that provide a structured platform for stakeholder engagement and collaborations with MSP experts and other scientists. The main aim of the workshops is to examine and discuss the progress in the MSP process, and provide new foundations to develop the project.

Workshop programme and participants

This workshop formed part of the Darwin PLUS funded project 'Developing Marine Spatial Planning (MSP) Tools for the Turks and Caicos Islands'

The aims of this workshop were to:

1. Agree on modelling approaches to identify ecologically important areas in the TCI marine environment
2. Identify data gaps
3. Agree on a small working group to contribute to modelling work
4. Develop an implementation plan to identify ecologically important areas for the TCI marine environment that will feed into the MSP process

The workshop took place over 4 mornings 28th & 29th September and 6th and 7th October 2020 at 9am – 12:30pm (TCI Time). Due to restrictions on travel and meetings imposed as a consequence of the COVID-19 pandemic, this workshop was held virtually using the Zoom software (see annex 1).

With the assistance of Bree Forrer and Debbie Barlow from SAERI, 5 ice breaker rooms of 4-5 people were organised. Participants were given 30 seconds – 1 minute to answer a question, such as what is your favourite marine animal and why? Before being whisked off to another room to answer the same question, with hopefully different people.

Over all 37 participants were involved in this workshop. The first day included 35 participants, with 13 people giving presentations 2 from the Turks and Caicos Island Government and 11 from scientists that had or are undertaking research projects in the Turks and Caicos Islands with questions and answer sessions. The second day included 33 participants and involved brain storming and discussions on the existing data. The third day included 29 participants and again involved brain storming and discussions on data quality and modelling approaches and agreeing on a small working group to contribute to modelling work. The fourth day involved 27 participants and included discussions on recommendations and important points raised from the previous days.

Participation

Table 1 workshop participants, their organisation and the days attended indicated by a 'Yes' in the days column.

Name	Organisation	Day 1	Day 2	Day 3	Day 4
Ms Cheryl-Ann Jones	Ministry of Tourism, Heritage, Environment, Gaming and Disaster Management and Emergencies Permanent Secretary	Yes	Yes	Yes	
Ms Lormeka Williams	Department of Environment and Coastal Resources	Yes		Yes	Yes
Dr Eric F. Salamanca	Department of Environment and Coastal Resources	Yes	Yes	Yes	
Mr Luc Clerveaux	Department of Environment and Coastal Resources	Yes	Yes	Yes	Yes
Ms Kathy Lockhart	Department of Environment and Coastal Resources	Yes	Yes	Yes	Yes
Ms Kate Chadwick	Department of Environment and Coastal Resources	Yes	Yes	Yes	Yes
Mr Bryan Manco	Department of Environment and Coastal Resources	Yes	Yes	Yes	Yes
Mr Roddy McCleod	Department of Environment and Coastal Resources	Yes		Yes	
Ms Jatavia Howell	Department of Environment and Coastal Resources	Yes	Yes	Yes	Yes
Ms Tyann Henry	Department of Environment and Coastal Resources	Yes	Yes	Yes	Yes
Mr Cyprian Smith	Survey and Mapping Department	Yes	Yes	Yes	
Mr Gervin Simmons	Survey and Mapping Department	Yes	Yes	Yes	Yes
Dr Heidi Hertler	School for Field Studies	Yes	Yes	Yes	Yes
Dr Ewa Krzyszczyk	School for Field Studies	Yes	Yes		
Ms Tara Pelembe	SAERI	Yes	Yes	Yes	Yes
Dr Paul Brickle	SAERI	Yes	Yes		
Dr Al Baylis	SAERI	Yes	Yes	Yes	Yes
Mr Marcin Gorny	SAERI	Yes	Yes	Yes	Yes
Dr Julian A. Tyne	SAERI	Yes	Yes	Yes	Yes
Dr Megan Tierney	Joint Nature Conservation Council	Yes	Yes	Yes	Yes
Ms Lucy Beagley	Joint Nature Conservation Council	Yes	Yes		
Ms Abbie Dosell	Joint Nature Conservation Council	Yes	Yes	Yes	Yes
Ms Sophie Neupauer	economics for the environment	Yes			
Ms Thecla S. Joseph	Maritime and Shipping	Yes	Yes	Yes	Yes
Mr. Rodman Johnson	Coastal Radar S	Yes	Yes	Yes	Yes
Ms. Ludwina Fulford	Department of Culture	Yes			
Dr Tammy Davies	Birdlife International	Yes	Yes	Yes	Yes
Mr Ian Davies	United Kingdom Hydrographic Office	Yes	Yes	Yes	Yes
Mr Leo McLeman	United Kingdom Hydrographic Office	Yes	Yes	Yes	Yes
Mr Amdeep Sanghera	MSCUK	Yes	Yes	Yes	Yes
Dr Jonathan Green	Seabird Ecology Group University of Liverpool	Yes	Yes	Yes	
Dr Rhiannon Austin	Seabird Ecology Group University of Liverpool	Yes	Yes	Yes	Yes
Professor Susan Baker	Cardiff University	Yes	Yes		
Dr Leanne Cullen-Unsworth	Cardiff University	Yes	Yes		
Dr Katie Medcalf	Environment Systems	Yes	Yes	Yes	Yes
Dr Debbie Bartlett	University of Greenwich	Yes	Yes	Yes	Yes
Dr Aaron Henderson	UAE University	Yes			

Day 1

On day one of the workshop, the Honourable Ms Cheryl-Ann Jones, Permanent Secretary for the Ministry of Tourism, Heritage, Environment, Gaming and Disaster Management and Emergencies, provided some opening remarks on behalf of the Turks and Caicos Island Government to officially start the workshop. This was followed by Ms Lormeka Williams Director of the DECR making some opening remarks and then a presentation by the Executive Director of SAERI Dr Paul Brickle. Round table introductions followed, and then Dr Julian A. Tyne presented an overview of the MSP project in TCI before the presentations started (Table 2). For more details on the presentations see annex 2

Table 2 Presentations on Day 1 of the workshop

Presentation	**Presenter**
Department of Environment and Coastal Resources	*Ms. Lormeka Williams DECR Director*
Department of Culture	*Ms. Ludwina Fulford Director*
Maritime and Shipping	*Ms. Thecla Joseph Director*
School for Field Studies	*Dr Heidi Hertler Director*
Mapping for evidence-based policy, recovery and environmental resilience	*Dr Katie Medcalf (Environment Systems)*
Sustainable solutions for Sargassum inundation in the Turks and Caicos Islands	*Dr Debbie Bartlett (Greenwich University)*
Turks and Caicos Islands Turtle Project	*Amdeep Sanghera (MCSUK)*
UKHO in TCI	*Ian Davies (UKHO)*
Regional scale marine conservation through multi-territory tracking of frigate birds	Dr Jonathan Green / Dr Rhiannon Austin (University of Liverpool)
Biodiversity and food security: developing collaborative policy for seagrass conservation	Professor Susan Baker (Cardiff University)
Elasmobranchs in TCI	Dr Aaron Henderson (UAE University)
Technical assistance programme for effective coastal-marine management in the TCI	Dr Megan Tierney (JNCC)
Caribbean Overseas Territories Regional Natural Capital Accounting Programme	Sophie Neupauer (eftec)
Stony Coral Tissue Loss Disease in TCI	Kathy Lockhart (DECR)

Day 2

Participants were divided into two breakout groups to discuss existing data (Table 3) and potential modelling approaches. Finally, the two groups re-convened for plenary session to discuss findings. These findings are included in the Key Recommendations section of this workshop report.

Table 3 existing habitat and mobile species data discussed during the workshop no economic or social data were considered as part of this workshop (annex 3).

Map	Brief Description
Queen Conch	Abundance of Queen Conch is number of individuals from visual surveys in 2013. The abundance was estimated by interviewing 28 fishermen using the waters around Turks and Caicos. Need more recent data. *Anecdotal fisher conch breeding grounds but need to be investigated further* 1. South Caicos Bank, South Bush Cay – Anecdotal fisher conch breeding area 2. South Caicos Bank – Anecdotal fisher conch breeding area 3. North East Caicos - Anecdotal fisher conch breeding area 4. PALSNP - Anecdotal fisher conch breeding area
Spiny Lobster	Abundance of spiny lobster is number of individuals indicated during a visual survey in 2013. The abundance was estimated by interviewing 28 fishermen using the waters around Turks and Caicos. Need more recent data. *Anecdotal fisher spiny lobster breeding grounds but need to be investigated further* 1. North West Point - Anecdotal fisher lobster breeding area year round 2. North East Caicos Bank - Anecdotal fisher lobster breeding area year round 3. South East Caicos Bank - Anecdotal fisher lobster breeding area year round Two areas are known to be important habitat for juvenile lobster: Gingerbread and East Bay around South Caicos (Bos, Clark, and Gore 2003)
Turtles	Aggregations of foraging and nesting turtles in TCI are dominated by juvenile green (*Chelonia mydas*) and hawksbill turtles (*Eretmochelys imbricate*) (Richardson et al. 2009). Key linkages have also recently been highlighted between the green turtles of the TCI and other distant habitats (Doherty et al. 2020). A recent study found that many sub-adult green turtles forage in the waters off Middle and East Caicos (Doherty et al. 2020). There are 20 turtle nesting sites identified around the TCI *(Eckert, Karen and Eckert, Adam 2019)*. Probably the most complete data set that we have.
Humpback Whales	Humpback whales migrate to the West Indies for their winter breeding season. The main aggregation for humpback whales is off the Dominican Republic at Silver Bank, Navidad Bank and Samaná

	Bay. An unknown number of humpback whales are observed annually off Salt Cay throughout the winter months (January – April) by residents and visitors. During three months of surveying in 2017, a total of 239 individual humpback whales among 154 groups were observed migrating through the area (MacKay et al. 2017).
Elasmobranchs	Spotted eagle ray (*Aetobatus narinari*), Blacknose shark (*Carcharhinus acronotus*), Caribbean reef shark (*Carcharhinus perezi*), Tiger shark (*Galeocerdo cuvier*), Nurse shark (*Ginglymostoma cirratum*), Southern stingray (*Hypanus americanus*), Lemon shark (*Negaprion brevirostris*), Great hammerhead shark (*Sphyrna mokarran*) species of elasmobranch identified around South Caicos using BRUVs (Bruns and Henderson 2020). A study assessing the value of Bell Sound nature reserve to lemon sharks in and around South Caicos, suggests that Bell Sound Nature Reserve is an important area to the local juvenile lemon shark population, with the habitat preference of the shallower waters of the reserve offering a greater level of protection from predation (Henderson, Jourdan, and Bell 2016). There is also discussion on the development of protection for sharks and rays in the TCI.
Coral reef, seagrass and mangrove distributions	Habitat units for these distributions are 30m – 40m resolution which is too course for robust modelling. Nature Conservancy habitat map is 10m resolution but requires ground truthing. Then there is the LiDAR data collected by the UKHO in 2018 and handed to the TCIG in January 2020 which has an extremely high resolution of 10cm ideal for robust habitat classification and subsequent modelling.
Sargassum	The most easterly islands, for example Grand Turk, are anecdotally reported to have the greatest quantity of sargassum deposited on the windward (east facing) beaches (Bartlett, Lee, and Myers 2019).
Protected Areas	Protected areas have been implemented in TCI since the 1980s there are now 35 protected areas, 11 national parks, 11 nature reserves, 4 sanctuaries and 9 areas of historical interest, 28 of these areas have a marine component.

Day 3

Dr Eric F. Salamanca (DECR) opened the day by providing some remarks. After the ice breaker Dr Al Baylis from the South Atlantic Environmental Research Institute (SAERI) gave a presentation on the 'Framework for mapping key areas of marine megafauna to inform MSP in the Falkland Islands (see annex 1).

From the previous day it was recommended that the data be divided into two categories, habitat (coral, seagrass, mangroves) and marine mobile species (marine mammals, elasmobranchs and sea turtles) due to the difference in approaches required to identify ecologically important areas for

each data type. Consequently, two breakout groups were formed to discuss modelling approaches and methodologies with the existing data for identifying ecologically important areas for habitat types and mobile species. The two groups then re-convened and a plenary session was held to discuss the outcomes of each group.

A working group to move forward with modelling approaches was agreed (Table 4)

Table 4 Agreed working group for developing modelling approaches to identify ecologically important areas

Name	Organisation
Dr Eric F. Salamanca	DECR Assistant Director for Research and Development
Ms Kathy Lockhart	DECR Assistant Director for Protected Areas, Fisheries and Revenue
Ms Kate Chadwick	DECR Fisheries Scientist
Ms Tyann Henry	DECR Environmental Officer
Dr Heidi Hertler	School for Field Studies Director
Dr Al Baylis	SAERI Deputy Director Science
Mr Marcin Gorny	SAERI GIS specialist and Data Manager
Dr Julian A. Tyne	SAERI Project Manager MSP TCI
Dr Tammy Davies	Birdlife International Marine Scientist
Mr Ian Davies	United Kingdom Hydrographic Office
Mr Amdeep Sanghera	MSCUK Overseas Territories Conservation Officer
Dr Rhiannon Austin	Seabird Ecology Group University of Liverpool
Prof Debbie Bartlett	University of Greenwich

Day 4

Luc Clerveaux (DECR) provided the opening remarks to start the day. After the icebreaker Dr Julian A. Tyne gave a presentation on the points raised during the previous days which was followed by a plenary session where key recommendations and points were discussed and are summarised below.

Key Recommendations

Determine priorities for Identifying Ecologically Important Areas

It was suggested during the workshop that modelling priorities need to be determined. The priorities of the Turks and Caicos Island Government are important in order to understand what should be targeted when identifying important ecological areas. Discussions with DECR to understand their priorities on identifying ecologically important areas with the existing data are required.

Need to separate approaches for important benthic areas and important areas for mobile species as different approaches for each category and need to consider both spatial and temporal data (life history stages).

Depending on target species, temporal data is also important, including threshold-based components such as the number of animal's that use a specific area, habitat type usage and what those ecological characteristics are. Lots of attributes to consider for each species such as age classes, population trends, their vulnerability (Red List Status) and national / global importance. Need to understand drivers and pressures.

Data

This workshop highlighted the challenges that the MSP project has had in acquiring existing data and the quality of that data. The spatial layers that have been created so far were said to be impressive and are helpful in understanding available and missing data. The data underlying these spatial layers may not be sufficient to provide robust modelling approaches. It was suggested that some data gap analysis be undertaken to determine missing data.

Benthic data

To identify ecologically important areas the ecological characteristics need to be understood to be able to infer their importance to a species or habitat. The habitat units for coral reef and seagrass distribution has a resolution of 30m – 40m quite course for a robust fine scale modelling approach. Caribbean coral reefs are classified as endangered (EN) by the IUCN Red List of Ecosystems.

Nature Conservancy benthic habitat map has a finer resolution of 10m, however it does require ground truthing. They can still be used in models for a broader identification of ecologically important areas around the TCI to provide a baseline.

The LiDAR data provided to the TCIG has an extremely high resolution of 10cm, and is ideal for fine scale habitat classification and mapping, and to be included in modelling approaches. The LiDAR data of the marine environment of TCI that was collected by the UKHO in 2018 and delivered to the TCIG in January 2020 has been particularly challenging to acquire. However, in the absence of a data sharing policy in the Turks and Caicos Islands it is difficult to obtain a copy of this very useful data. We are still working on an agreement to be able obtain a copy of these data.

Mobile species data

Sub-adult green turtle data layer is reasonably complete and of a high quality, although adult green turtle data is missing. The 25, 50, 75 and 90% utilisation distributions of sub-adult green turtles around Middle and East Caicos Islands, could be used to develop predictive models to identify other potentially important sub-adult green turtle areas around TCI. Green turtles are classified as endangered (EN) by the IUCN Red List.

Bell Sound Nature Reserve in South Caicos has been suggested as being important for juvenile lemon sharks. Lemon sharks are near threatened globally on the IUCN Red List (NT), with an unknown population trend. These data could also be used to develop predictive models to identify other potentially important juvenile lemon shark areas around TCI.

Identify more existing data, we have also just been provided with a 5-year time series of TCI shore bird count data and IBA/KBA spatial layers from Birdlife International.

Fisheries data is sensitive and fishermen are reluctant to divulge, although the queen conch and spiny lobster breeding areas where from fishermen, it's important to communicate with them to help acquire more accurate fisheries data.

Monitoring

Monitoring is important and is a core component to measure and estimate the impact of change over time. However, for monitoring to be effective it is also important when collecting data for monitoring purposes that the sampling design is systematic, repeatable, that results can be compared over time and is specific for desired analytical approaches. This would help to understand the drivers and pressures. Monitoring would also help to keep the data up to date.

Citizen science projects should be considered, can help with monitoring change over time and ground truthing. Dive operators and game fishers could be users of the citizen science applications. Need to determine what data these citizen science applications will be configured to collect and there will be a requirement for quality control of the data collected. Potentially target game fishers and dive operations.

Open/sharing data is important as it enables multiple uses of the same data sets and enables the identification of data gaps that can be targeted and addressed, and builds upon previous research.

Modelling

To be able to develop methodologies and models it is important to define the nature of and requirements for the analysis and be clear about methods available GAM, GAMM, Boosted GAMs, Simulations, Machine Learning. It might be beneficial to try and compare some modelling approaches on some existing data. These data can be used to train the models to identify ecologically important areas.

Data Gap Analysis

The main outcome of the workshop was to undertake some Data Gap Analysis (DGA) to identify data needs to be able to inform policy and to develop models to identify ecologically important areas around the TCI.

The working group will be tasked to undertake a data gap analysis for the Turks and Caicos Islands. To do this the group will have to understand the priorities when identifying important ecological areas around the Turks and Caicos Islands. What are goals are to be achieved from identifying important ecological areas around the Turks and Caicos Islands? What data currently exist and what data is still required, that can be used to help achieve these goals?

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Annex 1 – Workshop Programme

Day 1 - Presentations

Time	Topic	Presenter
9:00-9:05	*Housekeeping, etiquette*	*Dr Julian A. Tyne*
9:05 – 9:10	*Opening remarks*	*Ms Cheryl-Ann Jones permanent secretary for the Ministry of Tourism, Heritage, Environment, Gaming and Disaster Management and Emergencies*
9:10 – 9:15	*Opening remarks*	*Ms. Lormeka Williams DECR Director*
9:15– 9:25	*Opening remarks*	*Dr Paul Brickle / Tara Pelembe (SAERI)*
9:25 – 9:30	*Focus and aims of the workshop and this session*	*Dr Julian A. Tyne*
9:30– 10:00	Round Table introductions	Everyone
10:00 – 10:20	*Overview of MSP Project,*	*Dr Julian Tyne*
Turks and Caicos Government Departments Presentations		
10:20 – 10:25	*Department of Environment and Coastal Resources*	*Ms. Lormeka Williams DECR Director*
10:25 – 10:30	*Department of Culture*	*Ms. Ludwina Fulford Director*
10:30 – 10:35	*Maritime and Shipping*	*Ms. Thecla Joseph Director*
10:35 – 10:50	*Break*	
Research in the Turks and Caicos Islands Presentations		
10:50 – 10:55	*School for Field Studies*	*Dr Heidi Hertler Director*
10:55 – 11:00	*Mapping for evidence-based policy, recovery and environmental resilience*	*Dr Katie Medcalf (Environment Systems)*
11:00 – 11:05	*Sustainable solutions for Sargassum inundation in the Turks and Caicos Islands*	*Professor Debbie Bartlett (Greenwich University)*

11:05 – 11:10	*Questions*	
11:10 – 11:15	*Turks and Caicos Islands Turtle Project*	*Amdeep Sanghera (MCSUK)*
11:15 – 11:20	*UKHO in TCI*	*Ian Davies (UKHO)*
11:20– 11:25	*Regional scale marine conservation through multi-territory tracking of frigate birds*	Dr Jonathan Green / Dr Rhiannon Austin (University of Liverpool)
11:25 – 11:30	*Questions*	
11:30 – 11:35	*Biodiversity and food security: developing collaborative policy for seagrass conservation*	Professor Susan Baker (Cardiff University)
11:35 – 11:40	*Elasmobranchs in TCI*	Dr Aaron Henderson (UAE University)
11:40 – 11:45	*Technical assistance programme for effective coastal-marine management in the TCI*	Dr Megan Tierney (JNCC)
11:45 – 11:50	*Questions*	
11:50 – 11:55	*Caribbean Overseas Territories Regional Natural Capital Accounting Programme*	Sophie Neupauer (eftec)
11:55 -12:00	*Stony Coral Tissue Loss Disease in TCI*	Kathy Lockhart (DECR)
12:00 -	*Questions*	

Day 2 – Existing Data

Time	**Topic**	**Presenter**
9:00 – 9:15	*Opening remarks and introductions, aims of the session*	*Dr Julian Tyne*
9:15 – 9:30	*Ice breaker*	
9:30 – 9:50	*Intro to existing data*	*Dr Julian Tyne*
9:50 – 10:00	*Intro to WebGIS*	*Marcin Gorny*
10:00 -11:00 *10:00 – 10:20* *10:20 – 10:40*	*Breakout into 2 groups* *Discuss how to identify ecologically important areas with existing data* *Discuss types of criteria for identifying ecologically important areas* *How to prioritise those areas*	*Breakout into 2 groups*

10:40 – 11:00		
11:00 – 11:15	*Break*	
11:15 – 12:30	*Plenary discuss and consolidate the outcomes of the 2 breakout groups*	*Everyone*

	Data *Abundance of conch from visual surveys and fishermen interviews, anecdotal breeding grounds, seagrass.* *Abundance of lobster from visual surveys and fishermen interviews, anecdotal breeding grounds, important habitat for juvenile lobster* *Seagrass habitat distribution, conservation* *Coral reef distribution* *Mangrove habitat distribution* *Sargassum in TCI*	
	Elasmobranch species and distribution, nursery areas *Turtle species, nesting sites, tagging, genetics, area utilisation (important habitat)* *Marine Mammals, humpback whale migrations, resting areas*	

Day 3 – Methodologies

Time	Topic	Presenter

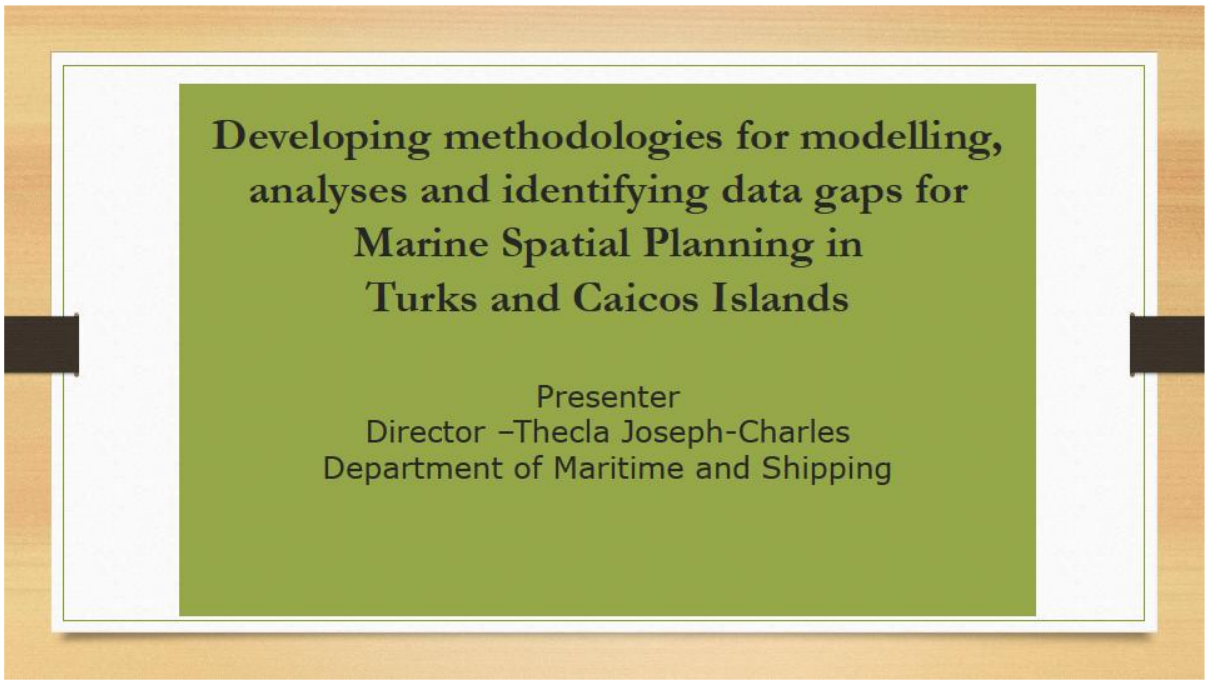
9:00 – 9:15	*Opening remarks and introductions, refresh from previous day, aims of this session*	*Dr Julian Tyne*
9:15 – 9:30	*Ice Breaker*	
9:30 – 9:50	*Framework for mapping key areas for marine megafauna to inform Marine Spatial Planning: The Falkland Islands case study*	*Dr Al Baylis (SAERI)*
9:50 – 10:50 *9:50 - 10:10* *10:10 – 10:30* *10:30 – 10:50* *10:50 – 11:10*	*2 breakout groups* *What approaches to modelling/analysis of existing data to identify ecologically important areas? Their strengths and weaknesses?* *What additional data would be useful for each approach?* *With current data and with additional data what approaches should be prioritise top 3 for each* *What modelling/analysis approaches would we recommend for identifying ecologically important areas*	*2 breakout groups*
11:10 – 11:30	*Break*	
11:30 – 12:30	*Plenary - Discuss and consolidate outcomes from each group and agree small working group for modelling/analysis work*	*Everyone*

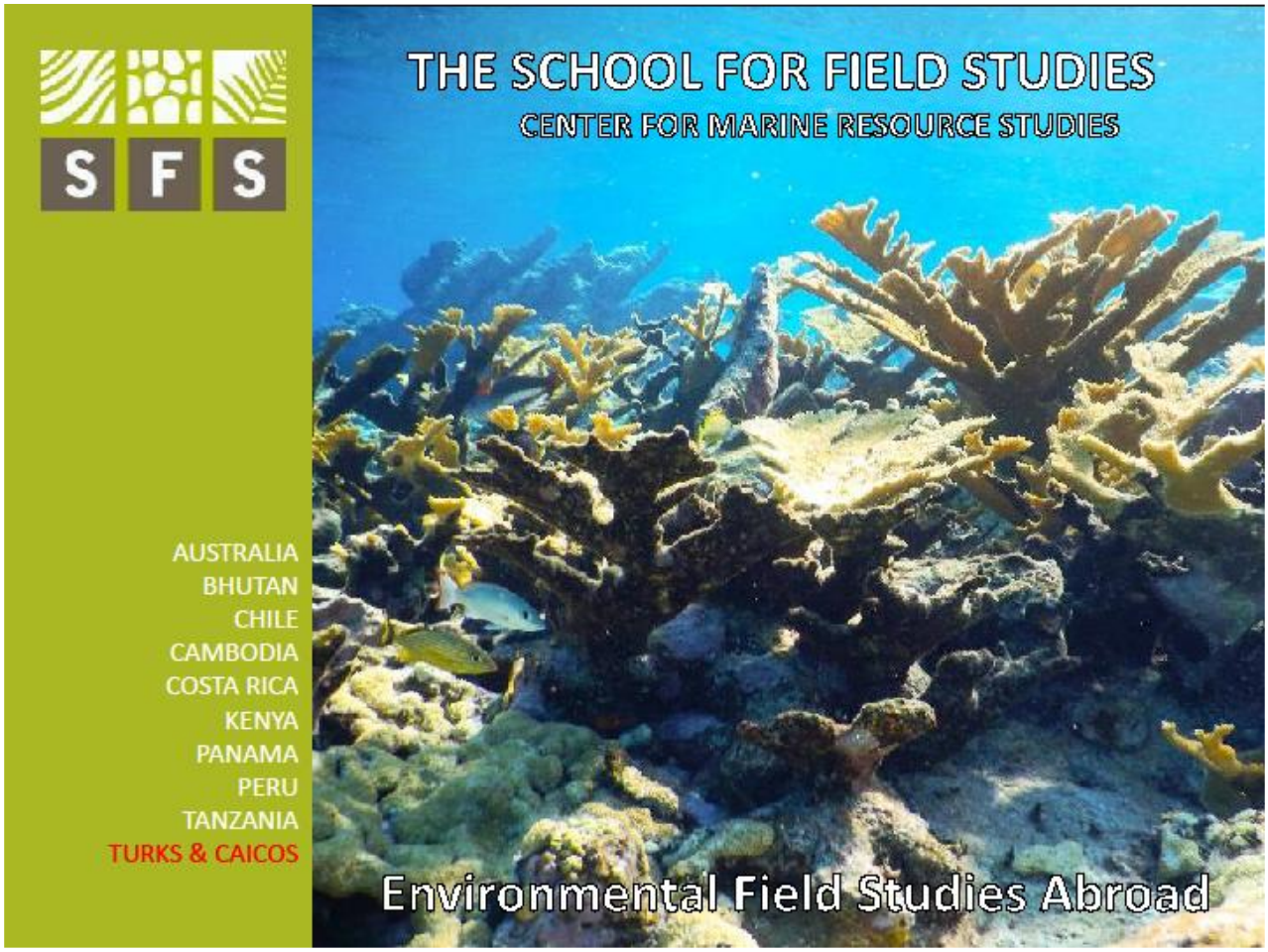
Day 4 - Developing the Tools

Time	Topic	Presenter
9:00 – 9:15	*Opening remarks and introductions, aims of the session, refresh from previous day*	*Dr Julian Tyne*
9:15 – 9:30	*Icebreaker*	

9:30 – 10:00	*From the previous day's session what approaches do we have and how are they prioritised*	*Everyone*
10:00 – 11:00	*Develop an implementation plan for identifying ecologically important areas to feed into MSP* *Outputs from the plan* • *Workshop report* • ***Multi-author publication*** • *Shape files for WebGIS* • *Metadata for data portal* • *Who will be working on these approaches* • *Timeline*	*Everyone*
10:45 – 11:00	*Break*	
11:00 – 12:15	*Develop an implementation plan for identifying ecologically important areas to feed into MSP continued* *Outputs from the plan* • *Workshop report* • ***Multi-author publication*** • *Shape files for WebGIS* • *Metadata for data portal* • *Who will be working on these approaches* *Timeline*	*Everyone*
12:15 – 12:30	*Wrap up*	*Dr Julian Tyne*

Annex 2 – Presentations





FACULTY OF ENGINEERING & SCIENCE

UNIVERSITY of GREENWICH

Sustainable solutions for Sargassum inundations in Turks & Caicos

Darwin Plus Round 7:

April 2019 – September 2021

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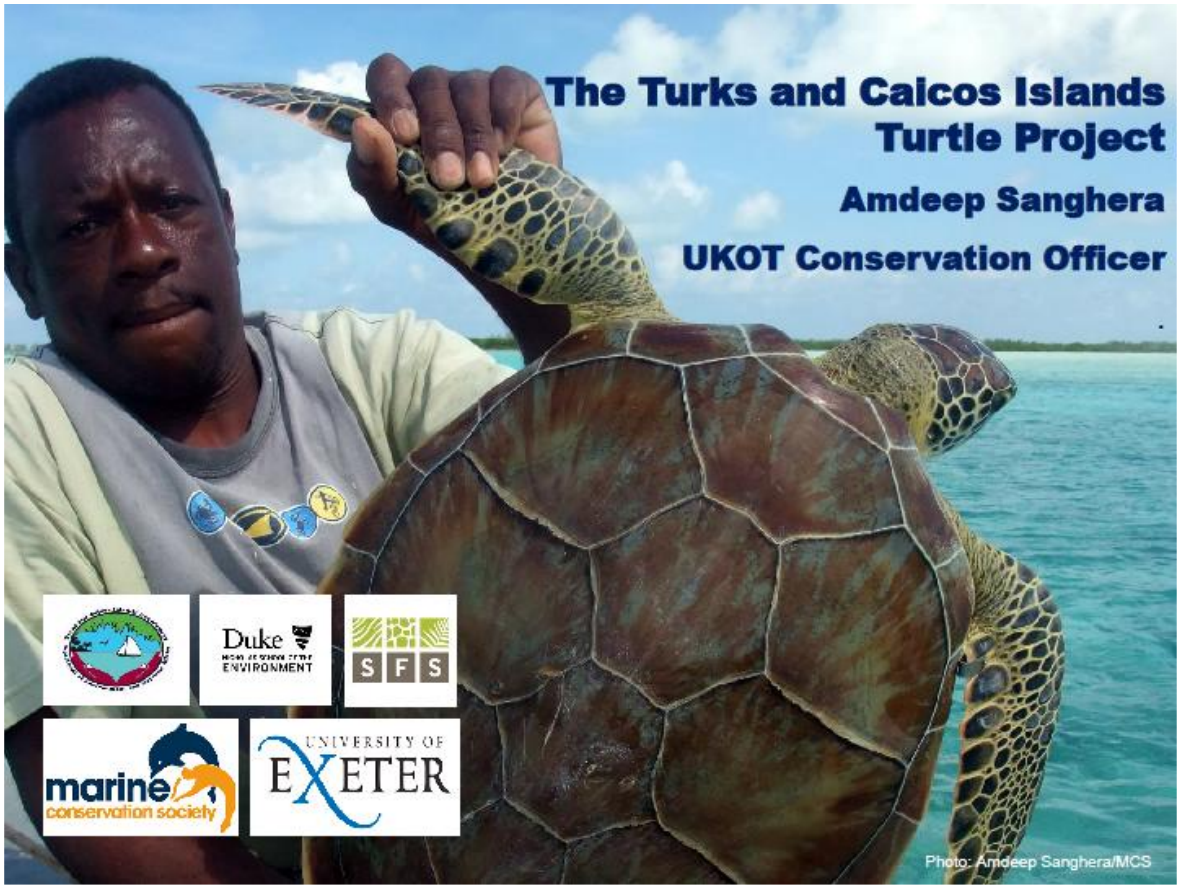

Caribbean Seabird Work

University of Liverpool - Dr Rhiannon Austin

TCI Workshop (DPLUS094), October 2020

MSP: Conservation of Seagrass Meadows in TCI and Lessons from Seychelles

Professor Susan Baker and Dr. Leanne Cullen-Unsworth

Talk presented at 'Developing methodologies for modelling, analyses and identifying data gaps for Marine Spatial Planning in Turks and Caicos Islands', workshop held by Department of Environmental and Coastal Resources, Ministry Tourism, Environment, Heritage, Maritime and Gaming and Turks and Caicos Islands Government, September- October 2020

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TCI Marine & Coastal Management Technical Assistance Programme

(DPLUS119)

TCI Environment Strategy

Dr Megan Tierney
Joint Nature Conservation Committee

Workshop on Developing MSP Tools for the TCIs
29 October 2020

eftec
economics for the environment

DPLUS108: Caribbean Overseas Territories regional natural capital accounting programme

Sophie Neupauer
Jake Kuyer

Alastair Baylis

TCI workshop 2020

Framework for mapping key areas for marine megafauna to inform Marine Spatial Planning: Falkland Islands case study

Annex 3 – Existing Data

Queen conch

Benthic habitat alone is not a good predictor of important conch recruitment and juvenile development habitat (Stoner 2003). Additional processes such as water circulation (oceanography) is required where larvae are concentrated, predation is low and survival high. Critical habitats for queen conch are defined by a combination of habitat features (benthos, depth, temperature, salinity) and ecological processes (oceanography, settlement, growth, mortality), (Stoner 2003).

The smallest juveniles are often found in bare sand or rubble environment rather than in seagrass and it has been hypothesized that settlement occurs on the shallow, bare substrata, where foods in the form of sediment-dwelling diatoms are abundant (Stoner 2003). The growth rates of 5 mm conch in sand are equivalent to those in adjacent seagrass, but slightly larger juveniles (11 and 22 mm) had significantly higher growth rates (and survival; see below) in seagrass. Conch nursery grounds are often associated with seagrass meadows with intermediate shoot density. Survivorship of juvenile conch within a seagrass meadow is strongly influenced by location (Stoner 2003).

The TCI Government is obligated to report their conch catches if they wish to continue to trade with signatory nations to the Convention of International Trade of Endangered Species of Wild Flora and Fauna (CITES). With the TCI only permitted to export conch to CITES signatories if it demonstrates a well-developed management plan, any lack of further action could see CITES effectively implement an export ban with the TCI (Ulman et al. 2016).

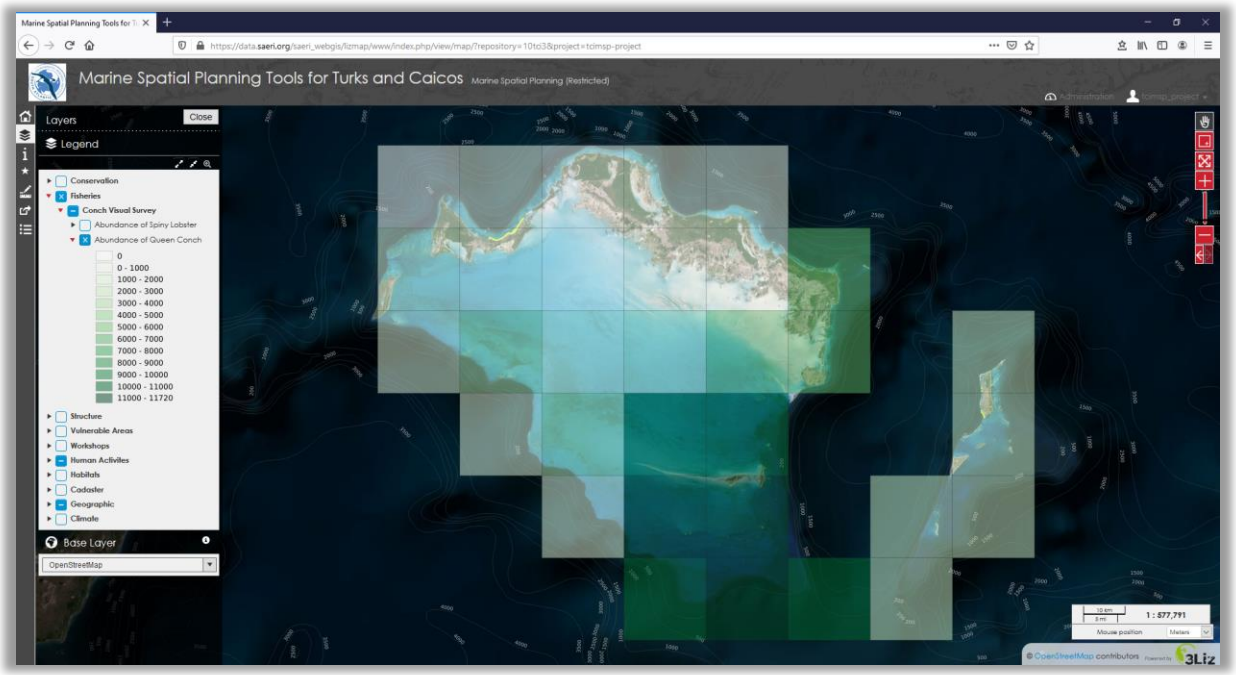


Figure 1 Abundance of Queen Conch is number of individuals from visual surveys in 2013. The abundance was estimated by interviewing 28 fishermen using the waters around Turks and Caicos.

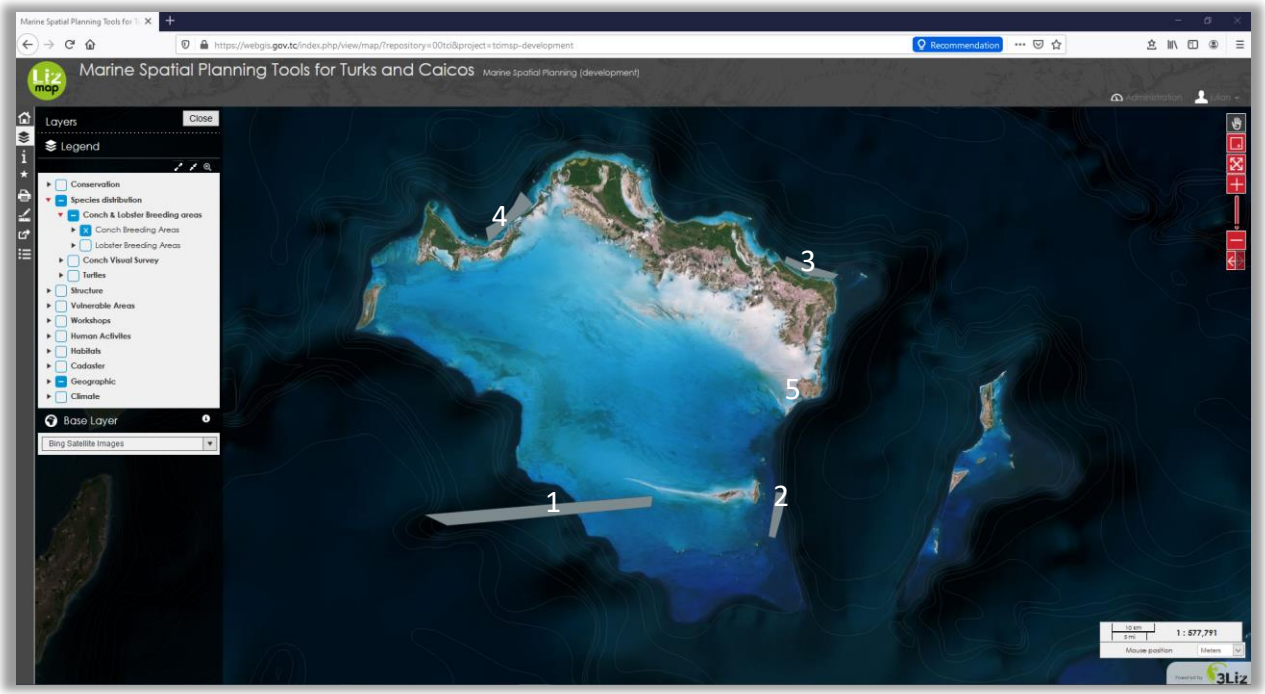


Figure 2 Anecdotal fisher conch breeding areas

1. South Caicos Bank, South Bush Cay – Anecdotal fisher conch breeding area
2. South Caicos Bank – Anecdotal fisher conch breeding area
3. North East Caicos - Anecdotal fisher conch breeding area
4. PALSNP - Anecdotal fisher conch breeding area
5. XSC - Anecdotal fisher conch breeding area

Spiny lobster

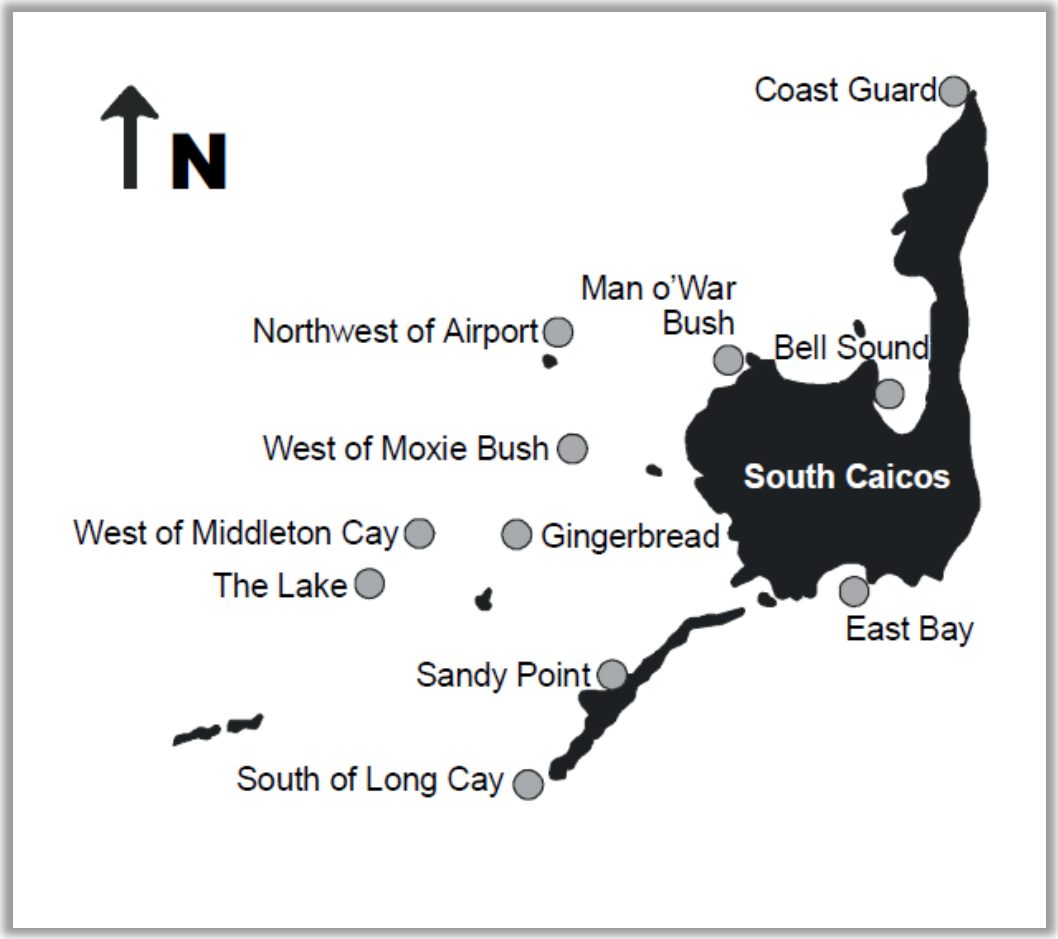


Figure 3 Areas where spiny lobster surveys were undertaken (Bos, Clark, and Gore 2003)

Two areas are known to be important habitat for juvenile lobster: Gingerbread and East Bay around South Caicos. Gingerbread was found to be an extensive area with *Neogoniolithon spp. (*crustaceous coralline algae) coverage of up to 50% (Bos, Clark, and Gore 2003). East Bay had densely covered areas with up to 80% of *Thalassia testudinum* and 10 to 20% of *Neogoniolithon* spp. Areas with a combined coverage of these two species contained high numbers of lobsters (Bos, Clark, and Gore 2003). Gingerbread was found to have a density of 138 lobster/ha, whereas East Bay was found to have a density of 1,199 lobster/ha. Lobster caught at East Bay were significantly smaller than lobster caught at Gingerbread (Bos, Clark, and Gore 2003).

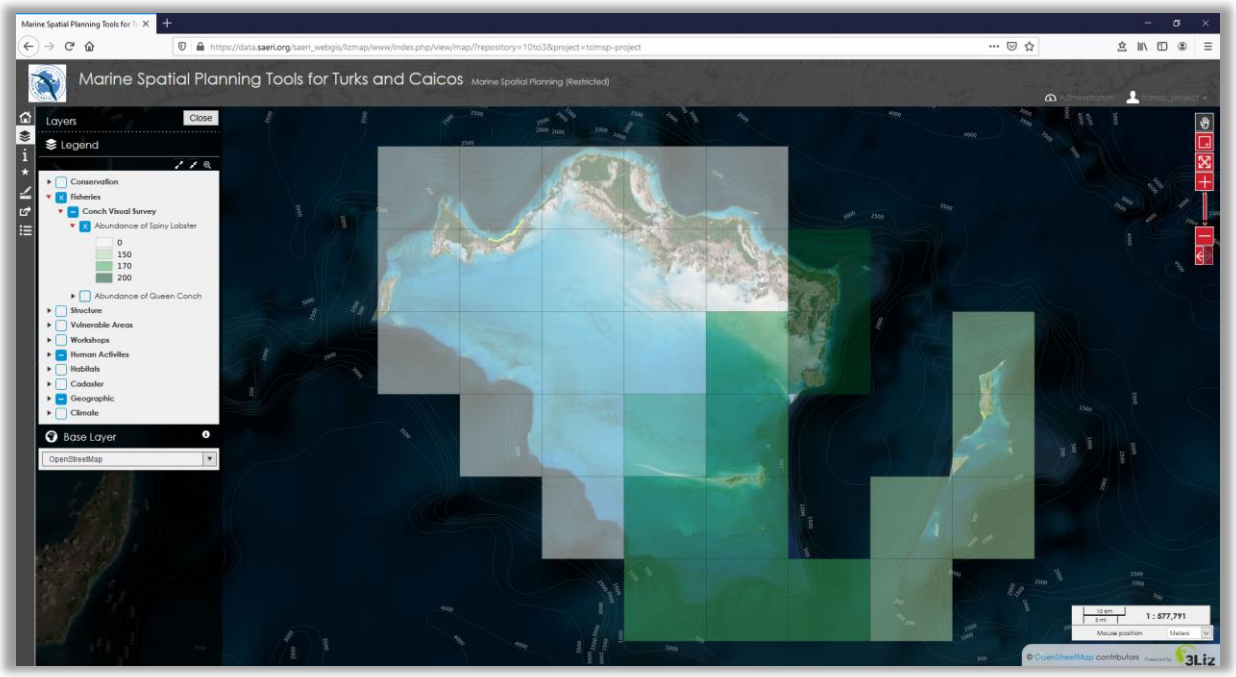


Figure 3 Abundance of spiny lobster is number of individuals indicated during a visual survey in 2013. The abundance was estimated by interviewing 28 fishermen using the waters around Turks and Caicos

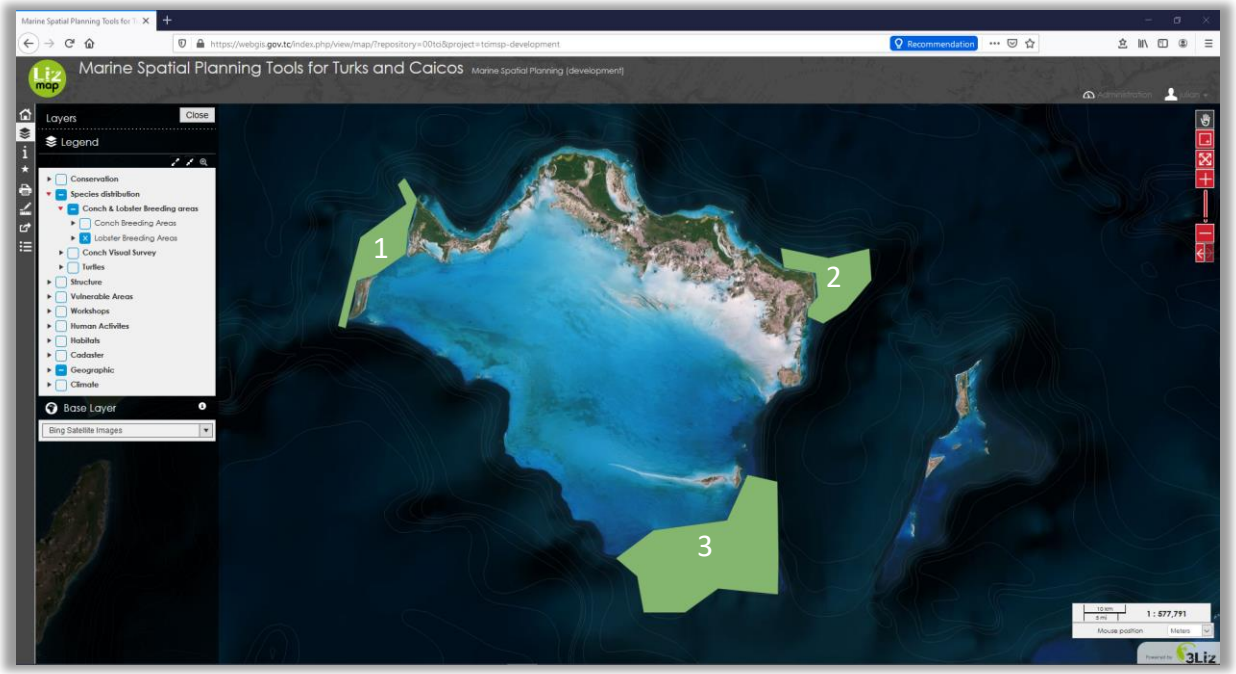


Figure 4 Anecdotal fisher spiny lobster breeding areas

1. North West Point - Anecdotal fisher lobster breeding area year round
2. North East Caicos Bank - Anecdotal fisher lobster breeding area year round
3. South East Caicos Bank - Anecdotal fisher lobster breeding area year round

Turtles

Aggregations of foraging and nesting turtles in TCI are dominated by juvenile green (*Chelonia mydas*) and hawksbill turtles (*Eretmochelys imbricate*). It has been suggested that these species aggregations originate from larger rookeries in the wider Caribbean. So TCI could be an important foraging area for these developing juvenile green turtles (Richardson et al. 2009).

Nesting season in TCI is from April to August. There is also a turtle fishery in TCI where the harvest of female nesting turtles and 'laid' turtle eggs is prohibited, any turtle at sea weighing more than 20 Ibs (9.07 kg) or measuring 20 inches (50.8 cm) from the 'neck scales to the tail piece' can be legally harvested year-round. It has been recommended that a maximum size limit be introduced to reduce the number of harvested larger turtled, which are critical for population viability (Stringell et al. 2013). Maximum size limit of a precautionary 61 cm and minimum size limit of 46 cm was introduced into legislation in 2014 (Stringell et al. 2015). Hawksbill close season is from August 1st until March 31st

Key linkages have also recently been highlighted between the green turtles of the TCI and other distant habitats such as in Colombia, South America (Doherty et al. 2020). Furthermore, the marine environment of the TCI provides critical areas for sub-adult green turtles to forage (Doherty et al. 2020), particularly in the waters off Middle and East Caicos (Doherty et al. 2020). These islands host extensive and largely pristine wetlands connected by a complex of tidal creeks vegetated by seagrass and marine algae (Richardson et al. 2009), providing rich foraging grounds to support the developmental and growth phases of sub-adult green turtles (Doherty et al. 2020). Given the nature of similar habitat within the Turks and Caicos Islands' both within and outside of MPAs, it is likely that this extensive network of marine habitats is of regional importance to Caribbean green turtles (Richardson et al., 2009).

Doherty et al. 2020 revealed region-wide connectivity across the Caribbean. Movements shown by satellite tracking crossed through nine geo-political zones, and into the High Seas; and international flipper tag recaptures occurring from waters of two other countries within the wider Caribbean as turtles travelled to other foraging grounds or toward natal beaches. These results emphasize the importance of establishing a cooperative network throughout the region to coordinate and support marine turtle management efforts especially when considering likely exposure to multiple fisheries (both legal and illegal), varying in regulation and enforcement levels, that will differ to those in TCI. However, there is still a paucity of knowledge on fine-scale information on movement within TCI waters, which would greatly improve ability to focus management efforts within and outside areas of protection.

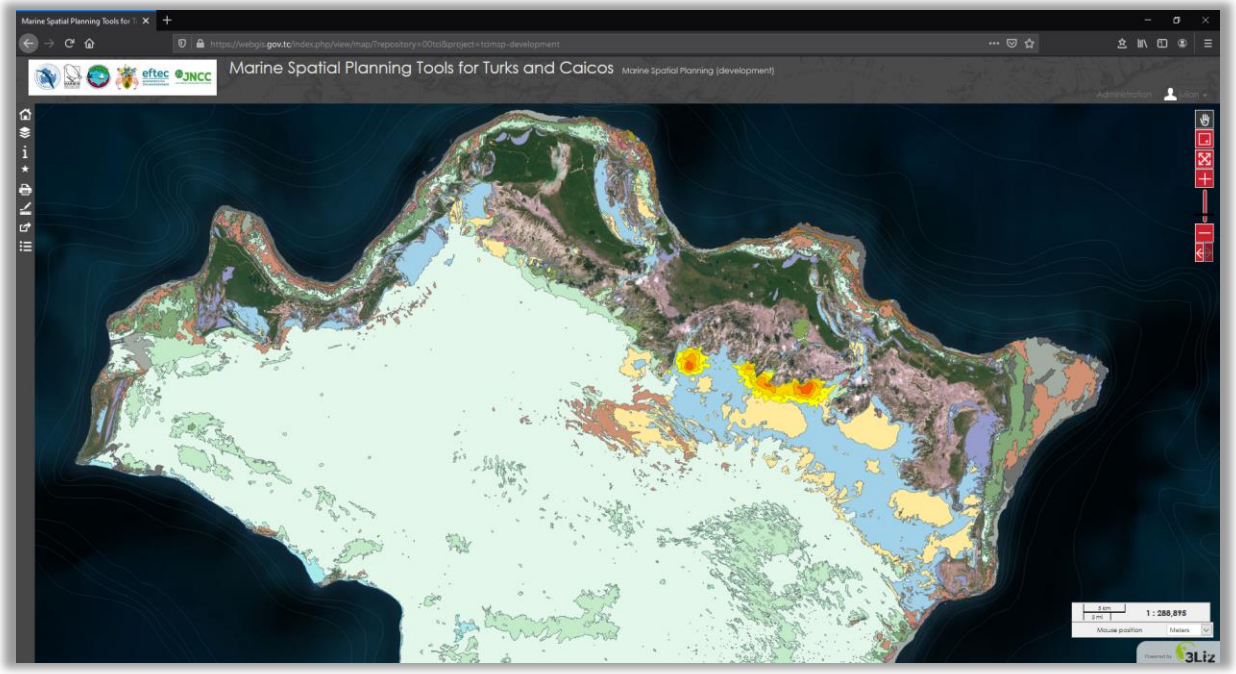


Figure 5 Juvenile green turtle 25, 50, 75 and 90% area utilisation distributions overlaid with benthic habitat on the WebGIS application

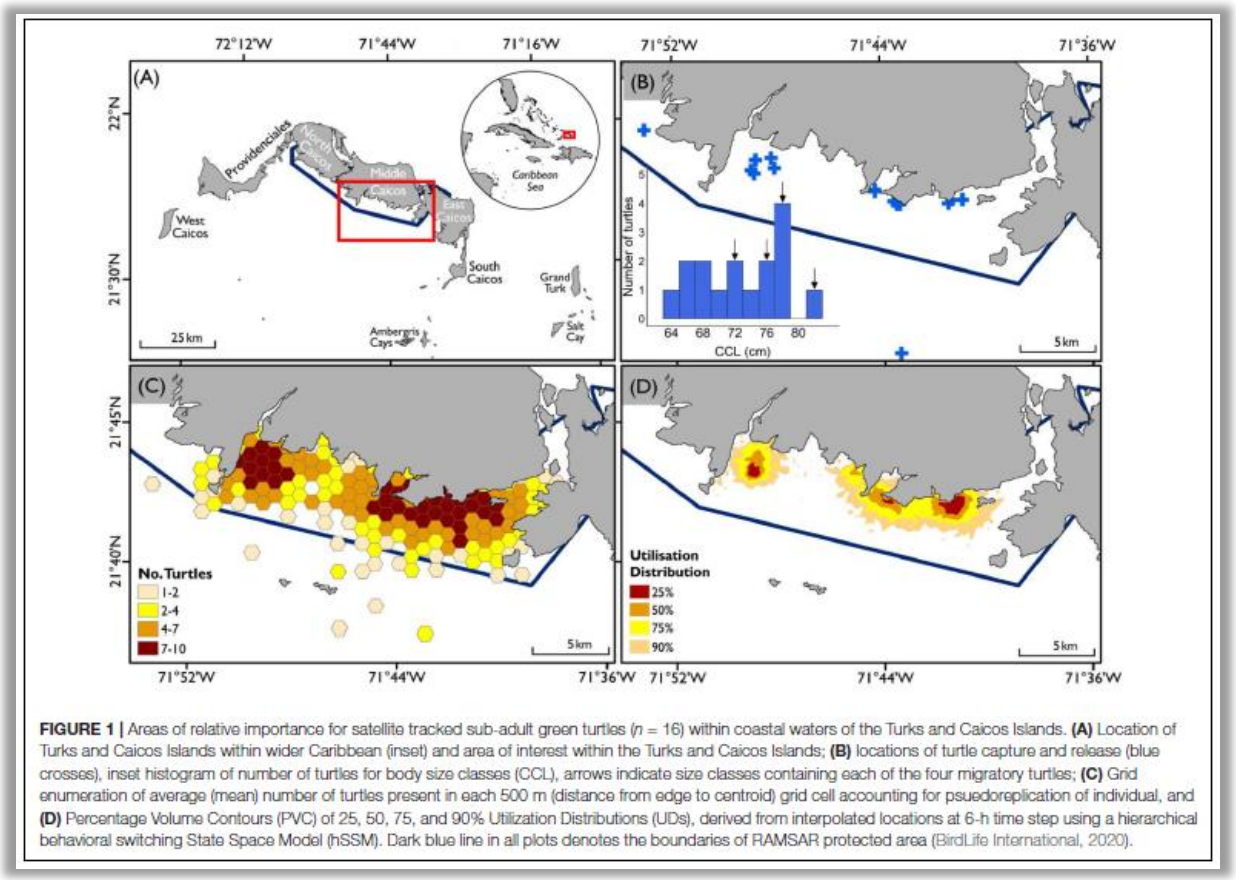


FIGURE 1 | Areas of relative importance for satellite tracked sub-adult green turtles (n = 16) within coastal waters of the Turks and Caicos Islands. **(A)** Location of Turks and Caicos Islands within wider Caribbean (inset) and area of interest within the Turks and Caicos Islands; **(B)** locations of turtle capture and release (blue crosses), inset histogram of number of turtles for body size classes (CCL), arrows indicate size classes containing each of the four migratory turtles; **(C)** Grid enumeration of average (mean) number of turtles present in each 500 m (distance from edge to centroid) grid cell accounting for psuedoreplication of individual, and **(D)** Percentage Volume Contours (PVC) of 25, 50, 75, and 90% Utilization Distributions (UDs), derived from interpolated locations at 6-h time step using a hierarchical behavioral switching State Space Model (hSSM). Dark blue line in all plots denotes the boundaries of RAMSAR protected area (BirdLife International, 2020).

Figure 6

(Doherty et al. 2020)

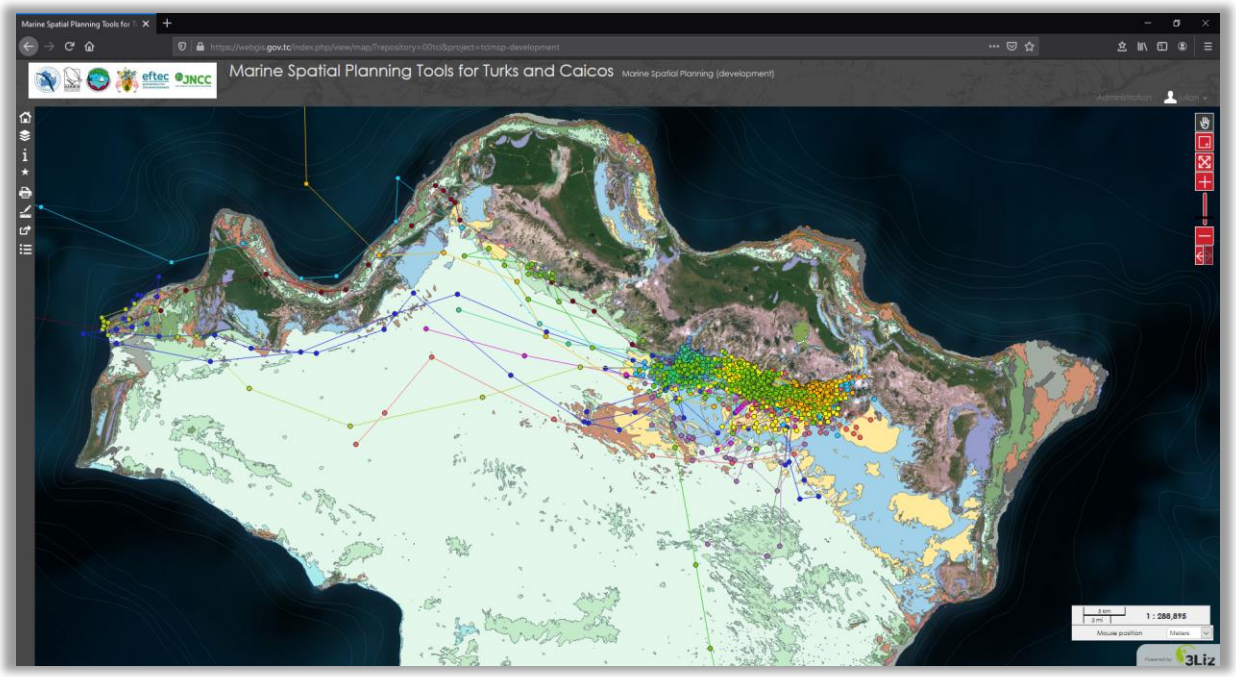


Figure 7 Juvenile green turtle tracks overlaid with benthic habitat on the WebGIS application

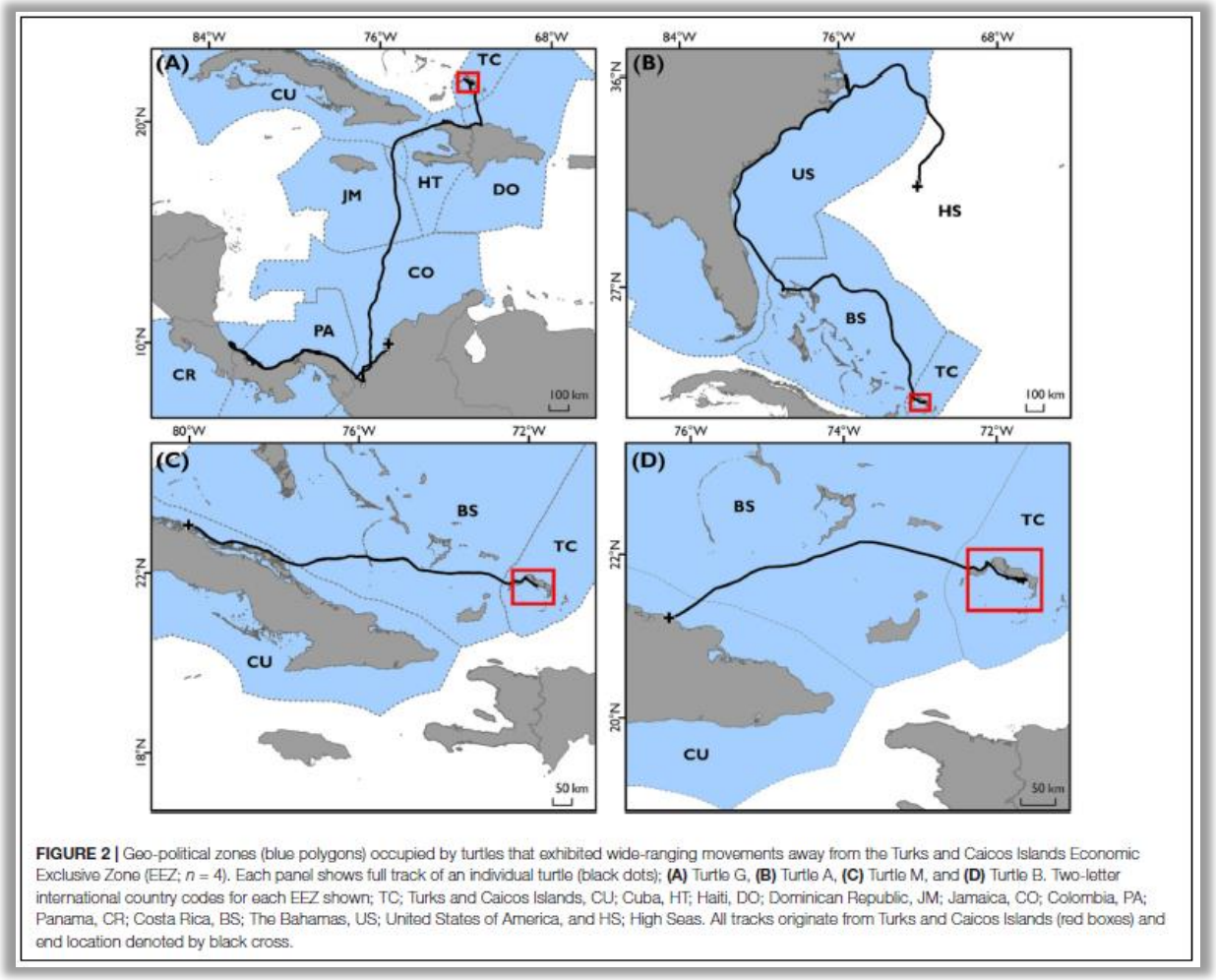
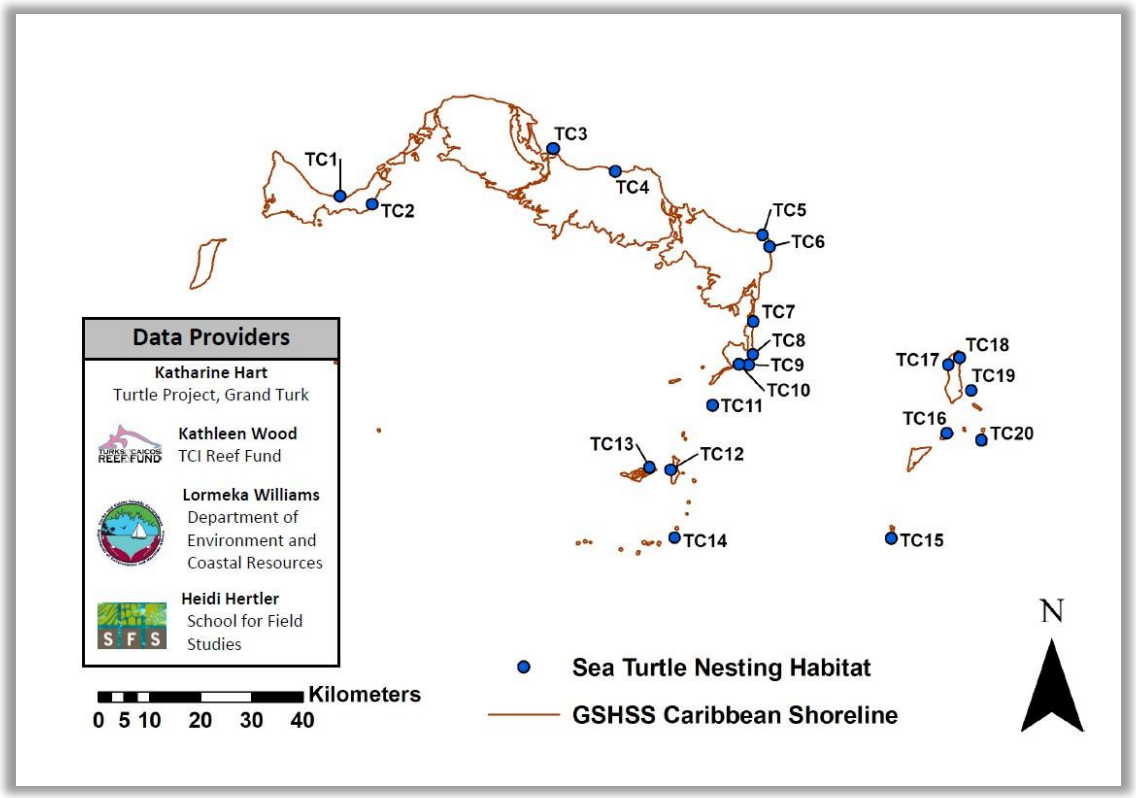


FIGURE 2 | Geo-political zones (blue polygons) occupied by turtles that exhibited wide-ranging movements away from the Turks and Caicos Islands Economic Exclusive Zone (EEZ; *n* = 4). Each panel shows full track of an individual turtle (black dots); **(A)** Turtle G, **(B)** Turtle A, **(C)** Turtle M, and **(D)** Turtle B. Two-letter international country codes for each EEZ shown; TC; Turks and Caicos Islands, CU; Cuba, HT; Haiti, DO; Dominican Republic, JM; Jamaica, CO; Colombia, PA; Panama, CR; Costa Rica, BS; The Bahamas, US; United States of America, and HS; High Seas. All tracks originate from Turks and Caicos Islands (red boxes) and end location denoted by black cross.

Figure 8

(Doherty et al. 2020)



Beach Identification Codes with Beach Names			
TC1	Grace Bay Beach	TC11	Fish Cay
TC2	Long Bay - Providenciales	TC12	Big Ambergris Cay
TC3	Highas Cay—North Caicos	TC13	White Cay
TC4	Bambarra Beach	TC14	Bush Cay
TC5	North Beach—East Caicos	TC15	Big Sand Cay
TC6	Long Bay – East Caicos	TC16	Cotton Cay
TC7	McCartney Key	TC17	Grand Turk (W)
TC8	Long Beach, South Caicos	TC18	Grand Turk (E)
TC9	Shark Bay, South Caicos	TC19	Gibbs Cay
TC10	East Bay, South Caicos	TC20	Eastern Cay

Figure 9 Turtle nesting sites of the Turks and Caicos Islands (Eckert, Karen and Eckert, Adam 2019)

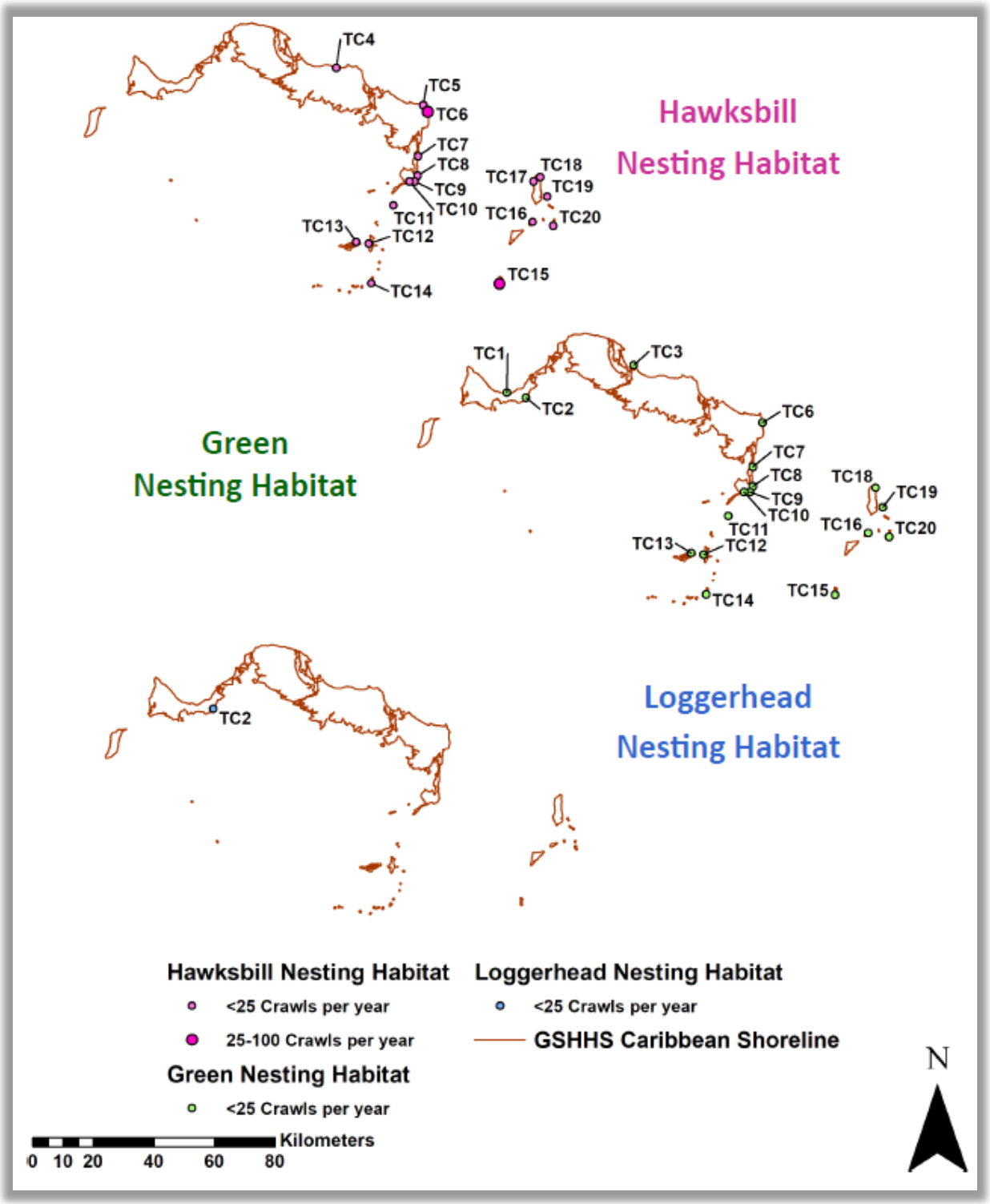


Figure 10 Turtle nesting sites by species of the Turks and Caicos Islands (Eckert, Karen and Eckert, Adam 2019)

Marine Mammals

Humpback whales migrate to the West Indies for their winter breeding season. The main aggregation for humpback whales is off the Dominican Republic at Silver Bank, Navidad Bank and Samaná Bay. An unknown number of humpback whales are observed annually off Salt Cay throughout the winter months (January – April) by residents and visitors. During three months of

surveying in 2017, a total of 239 individual humpback whales among 154 groups were observed migrating through the area (MacKay et al. 2017).

We've found out a lot more about the whales since we've started doing photo ID, and even though MCERC haven't been present in-person on the island, we've managed to get most of the whale watching operators on board submitting photos. Cathy Bacon from MCERC then goes through the full catalogue and has been matching whales for us. Before this, we weren't sure if the whales were just passing through here on the way to the Silver Bank in the Dominican Republic or to Puerto Rico. What we're seeing now is that some are certainly passing through, while others spend a more prolonged period of time here. We've had matches to Nova Scotia, the Gulf of Maine and Newfoundland, and this year our first match to Norway! We've also identified whales here with new calves in different seasons. This year, we were also able to identify a mother and her year-old calf that were there the previous season (Katharine Hart, pers. Comm.)

The whales are sighted off Provo and the Caicos Islands, but typically their behaviour is different around there. They are usually in deeper water and travelling. On the Turks Bank, we find them in the shallows between Cotton Cay/Salt Cay and on the east side of Salt Cay. They tend to be nursing and resting in those areas. We have no regulations at all for whale watching here, which is becoming a serious problem as swimming with whales is now all-over social media (Katharine Hart, pers. Comm.)

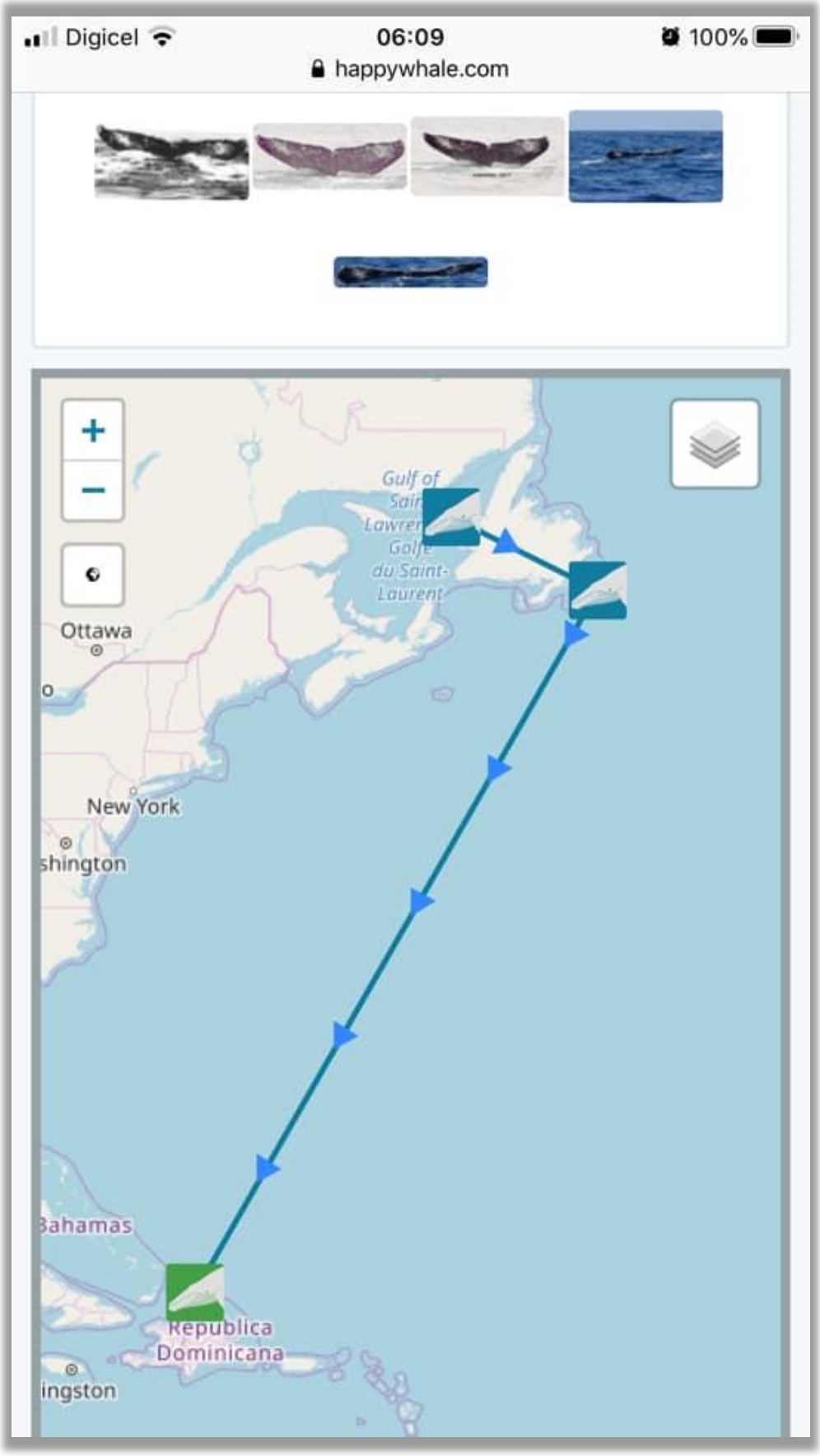


Figure 11 Humpback whale identified in the Gulf of St Lawrence, also identified in TCI

Preliminary data suggests humpback whales are utilizing the Columbus Passage, the area between the Caicos Bank and the Turks Bank in the TCI, as a corridor between the northern feeding grounds and the breeding areas throughout the Caribbean. Individuals are rarely re-sighted, with exceptions including mother calf pairs for 3 days or less. Tagging may be of value in the TCI as a means of collecting valuable data on migration and movement in both directions each winter (MacKay et al. 2017).

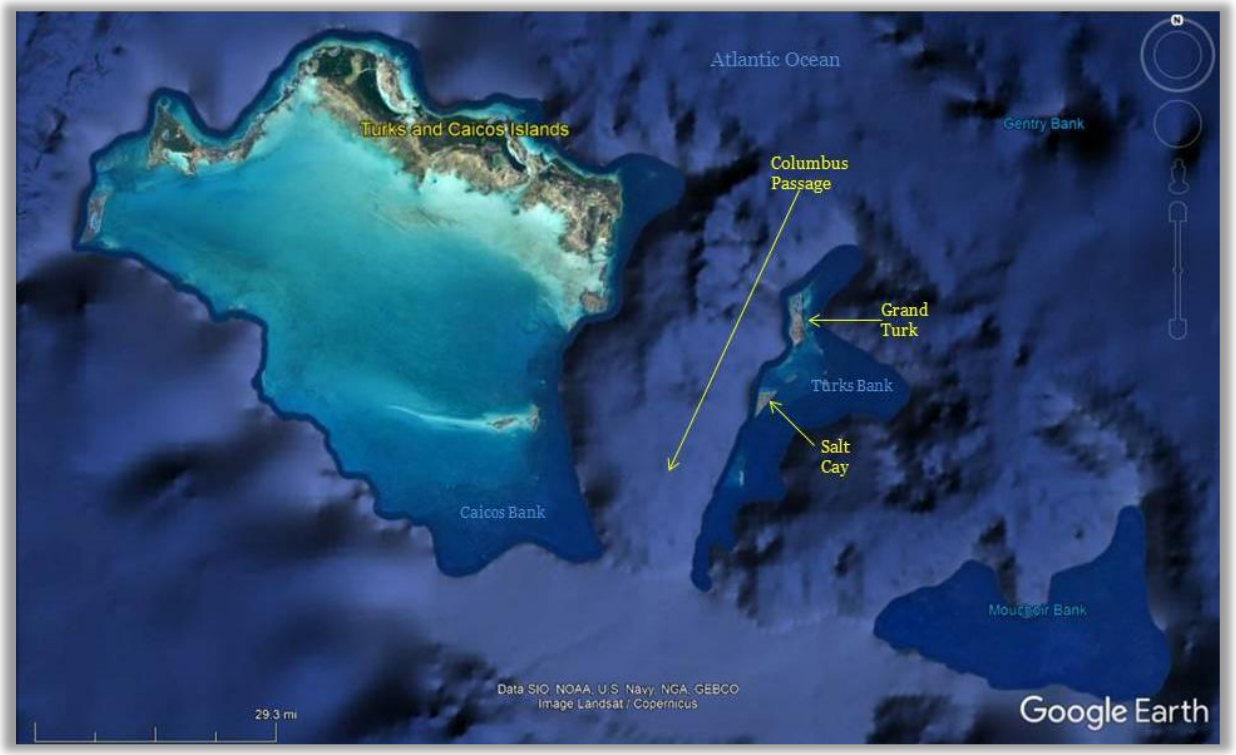


Figure 12 Columbus passage through which humpback whales migrate between the Caicos and Turks Island

Elasmobranchs

Using baited remote underwater video systems (BRUVS), the nurse shark *Ginglymostoma cirratum*, Caribbean reef shark *Carcharhinus perezi*, spotted eagle ray *Aetobatus narinari*, southern stingray *Hypanus americanus*, lemon shark *Negaprion brevirostris*, tiger shark *Galeocerdo cuvier*, blacknose shark *Carcharhinus acronotus*, and great hammerhead shark *Sphyrna mokarran* were observed to use these waters, with *G. cirratum* and *C. perezi* being particularly abundant. Species diversity and overall abundance was greater in the reef environment than on the sand flats, but *G. cirratum* was equally abundant in both environments. Furthermore, even reef associated species such as *C. perezi* were occasionally encountered on the flats a considerable distance from the reef. This indicates that although marine conservation efforts in the Turks and Caicos Islands should continue to focus on coral reef areas, less dramatic environments such as sand flats should not be ignored (Bruns and Henderson 2020).

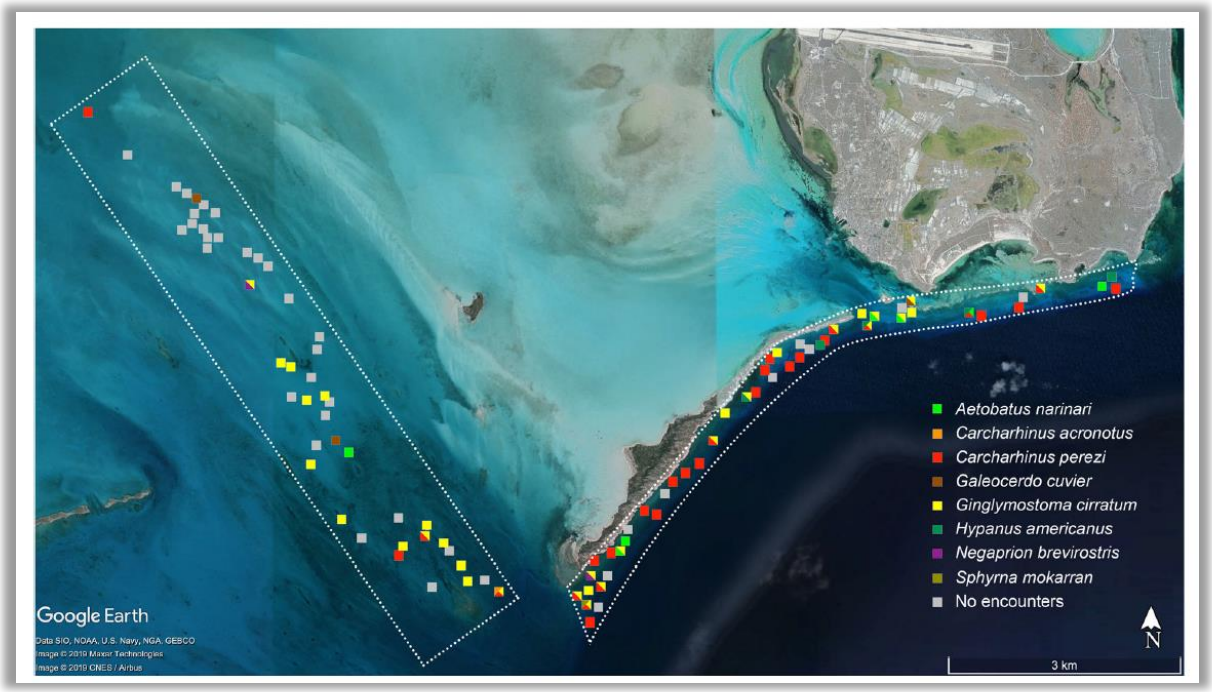


Figure 13 Elasmobranchs identified using BRUVs off South Caicos (Bruns and Henderson 2020)

Spotted eagle ray (*Aetobatus narinari*), Blacknose shark (*Carcharhinus acronotus*), Caribbean reef shark (*Carcharhinus perezi*), Tiger shark (*Galeocerdo cuvier*), Nurse shark (*Ginglymostoma cirratum*), Southern stingray (*Hypanus americanus*), Lemon shark (*Negaprion brevirostris*), Great hammerhead shark (*Sphyrna mokarran*) Expected but, no blacktip shark (Carcharhinus limbatus), Cribbean sharpnose shark (Rhizoprionodon porosus), bull shark (Carcharhinus Leucas) (Bruns and Henderson 2020).

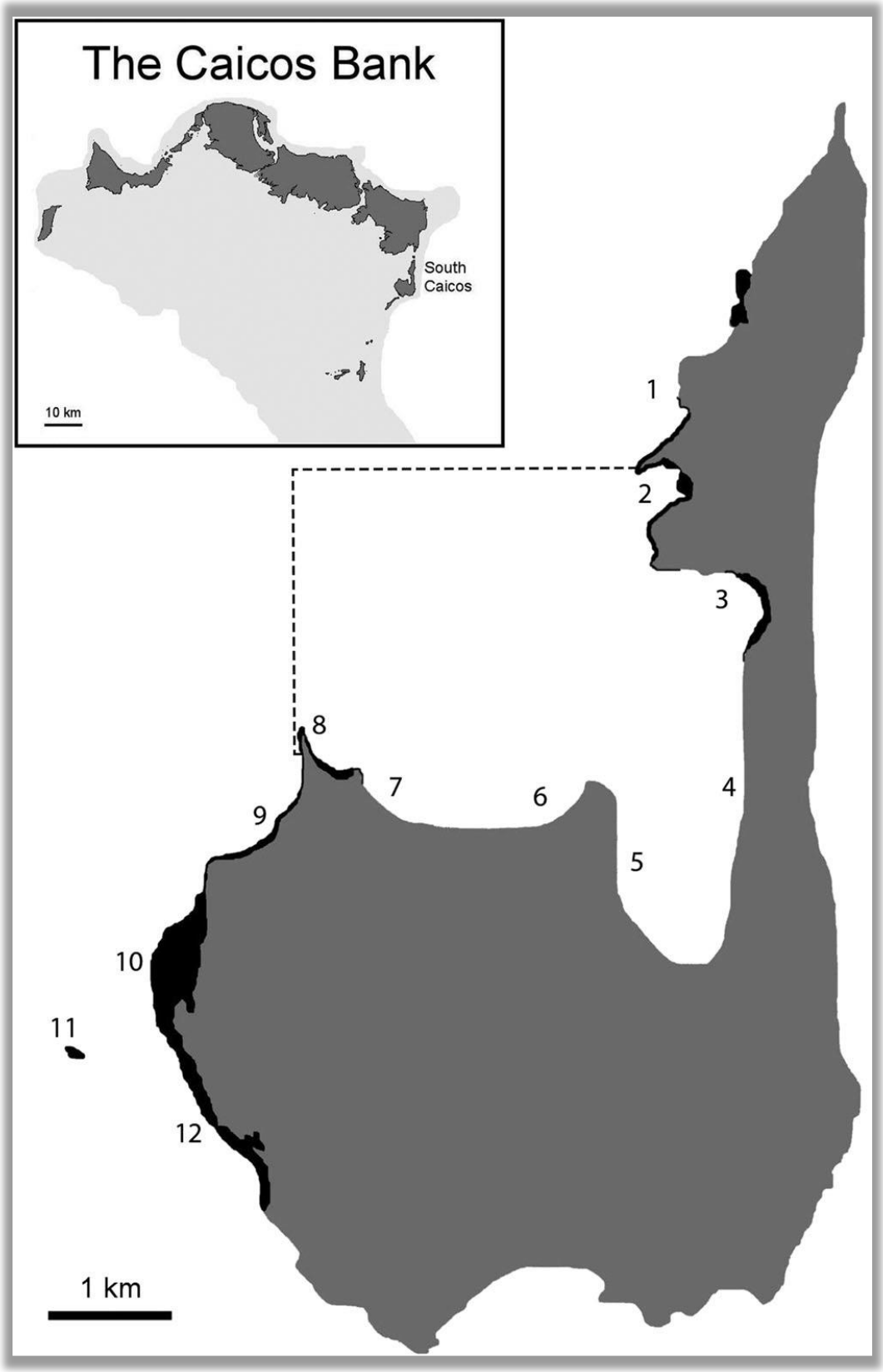


Figure 14 The locations of sampling sites around South Caicos during the present study. 1 = Sail Rock North, 2 = Sail Rock South, 3 = Bell Sound North, 4 =Bell Sound East, 5 = Bell Sound West, 6 = East Wall, 7 = West Wall, 8 = Man-O-War Bush, 9 = Airport, 10 = Little Man-O-War Bush, 11 = Moxy Bush, 12 = John Dean Bay. The dashed line represents the boundary of the Bell Sound Nature Reserve (Henderson, Jourdan, and Bell 2016).

Table 4 Habitat type of study areas around South Caicos (Henderson, Jourdan, and Bell 2016).

Site	Shore type	Substrate	Benthic vegetation	Depth (1)	Depth (2)
Sail Rock North (1)	mangrove	firm	minimal	0.3 m	1.3 m
Sail Rock South (2)	mangrove	soft	moderate	0.8 m	2.3 m
Bell Sound North (3)	limestone/mangrove	firm	moderate	0.1 m	1.6 m
Bell Sound East (4)	sandy	firm	minimal	0.1 m	1.4 m
Bell Sound West (5)	limestone	firm	minimal	0.9 m	2.5 m
East Wall (6)	sandy	firm	minimal	0.1 m	1.5 m
West Wall (7)	sandy/mangrove	soft	minimal	0.1 m	1.2 m
Man-O-War Bush (8)	mangrove	soft	moderate	0.4 m	1.4 m
Airport (9)	mangrove	soft	moderate	0.4 m	1.5 m
Little Man-O-War (10)	mangrove	soft	moderate	0.4 m	1.5 m
Moxy Bush (11)	mangrove	firm	minimal	0.5 m	1.2 m
John Dean Bay (12)	mangrove	soft	moderate	0.5 m	1.4 m

For an area to be designated a shark nursery, sharks must be more commonly encountered there than in other areas; they must remain in, or return to, the area for extended periods; the area must be used repeatedly across years (Henderson, McClellan, and Calosso 2010) . Although juvenile lemon sharks were present around South Caicos throughout the year, and their size distribution suggests that up to four-year classes were present, the transient nature of individuals around South Caicos and the occurrence of juvenile lemon sharks in adjacent areas dictates that South Caicos is only part of a larger, more expansive nursery ground (Henderson, McClellan, and Calosso 2010).

The Caicos Bank experiences strong tidal currents and the sites with the highest CPUE in the present study (Man-O-War Bush, John Dean Bay and Moxy Bush) are all exposed to strong tidal movements, whereas the lowest CPUE sites (East Bay and Bell Sound) are more sheltered. Furthermore, the capture/recapture of sharks between Moxy Bush and John Dean Bay illustrates the mobility of the South Caicos sharks. A further study assessing the value of Bell Sound nature reserve to lemon sharks in and around South Caicos, suggests that Bell Sound Nature Reserve is an important area to the local juvenile lemon shark population, with the habitat preference of the shallower waters of the reserve offering a greater level of protection from predation (Henderson, Jourdan, and Bell 2016).

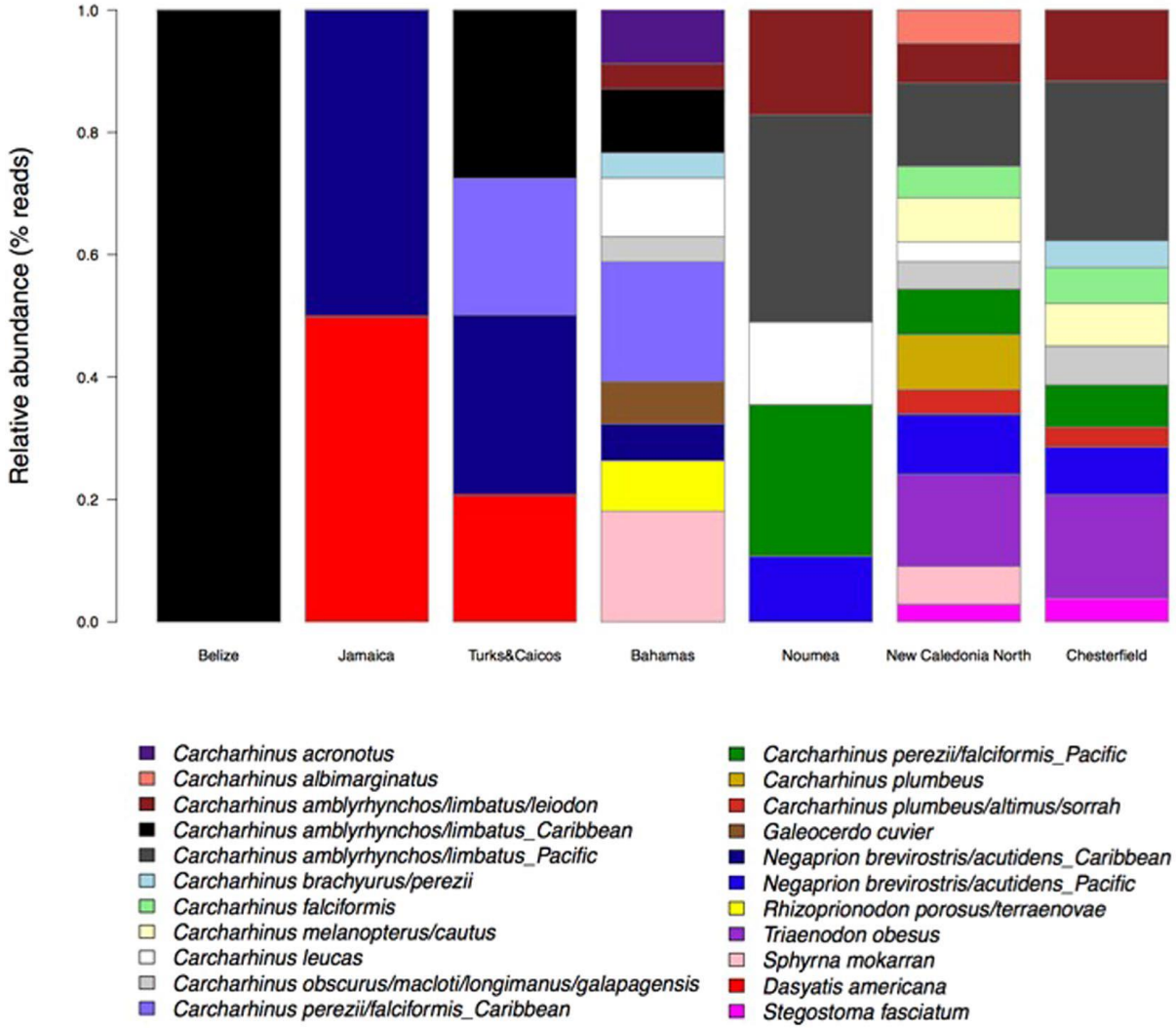


Figure 15 Bar plot showing the relative abundances of reads (fourth-root transformed) for every elasmobranch Molecular Operational Taxonomic Unit (MOTU) detected in the Caribbean and New Caledonian locations (Bakker et al. 2017)

Southern stingray (*Dasyatis Americana*), Lemon shark (*Negaprion brevirostris*), Caribbean reef shark (*Carcharhinus perezii)* and Grey reef shark *(carcharhinus amblyrhynchos)* identified in the Turks and Caicos Islands.

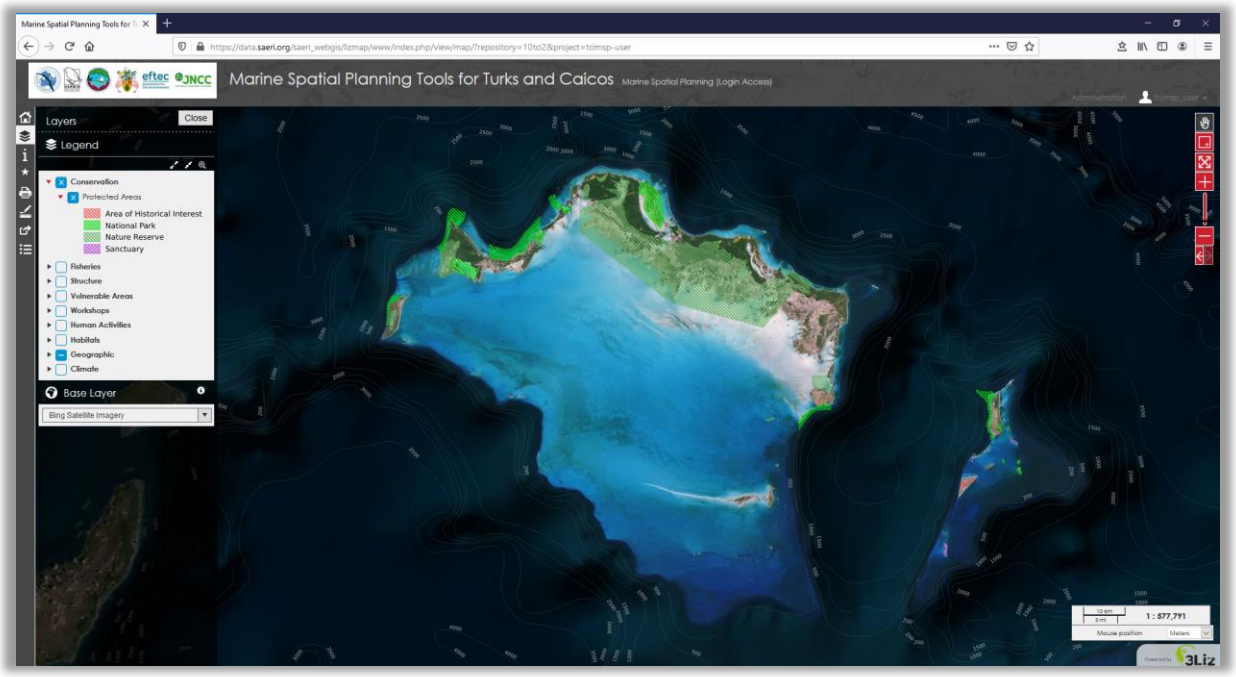


Figure 16 Protected Areas

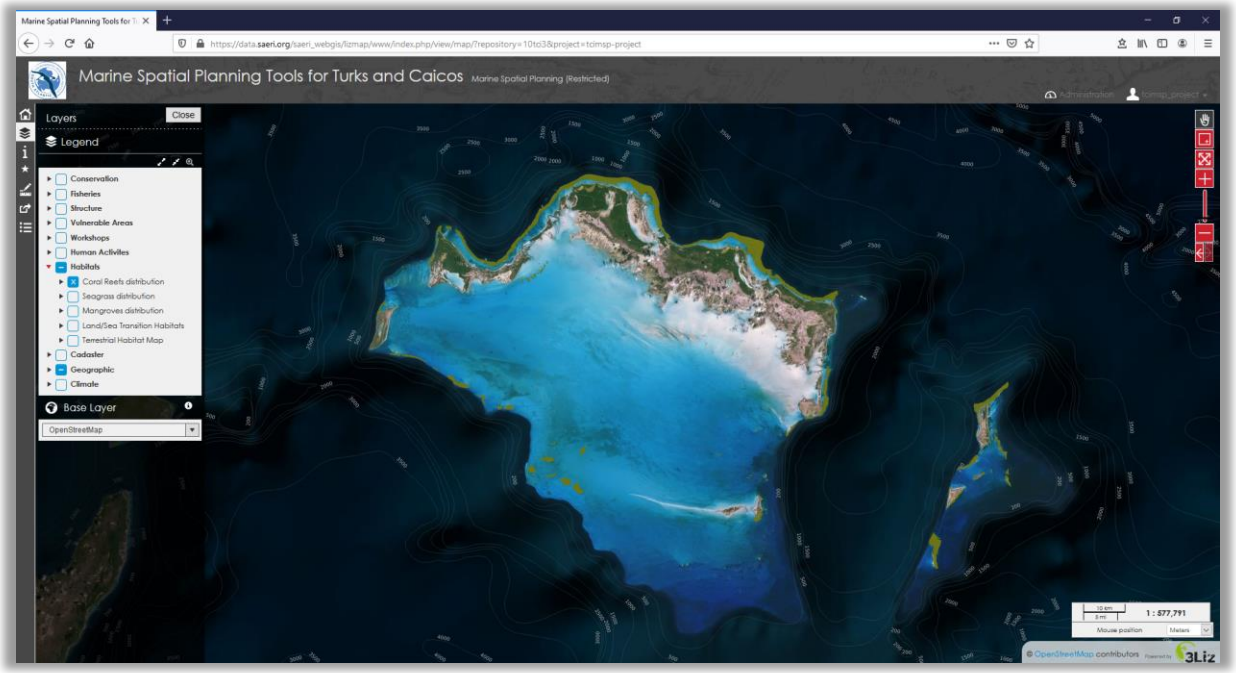
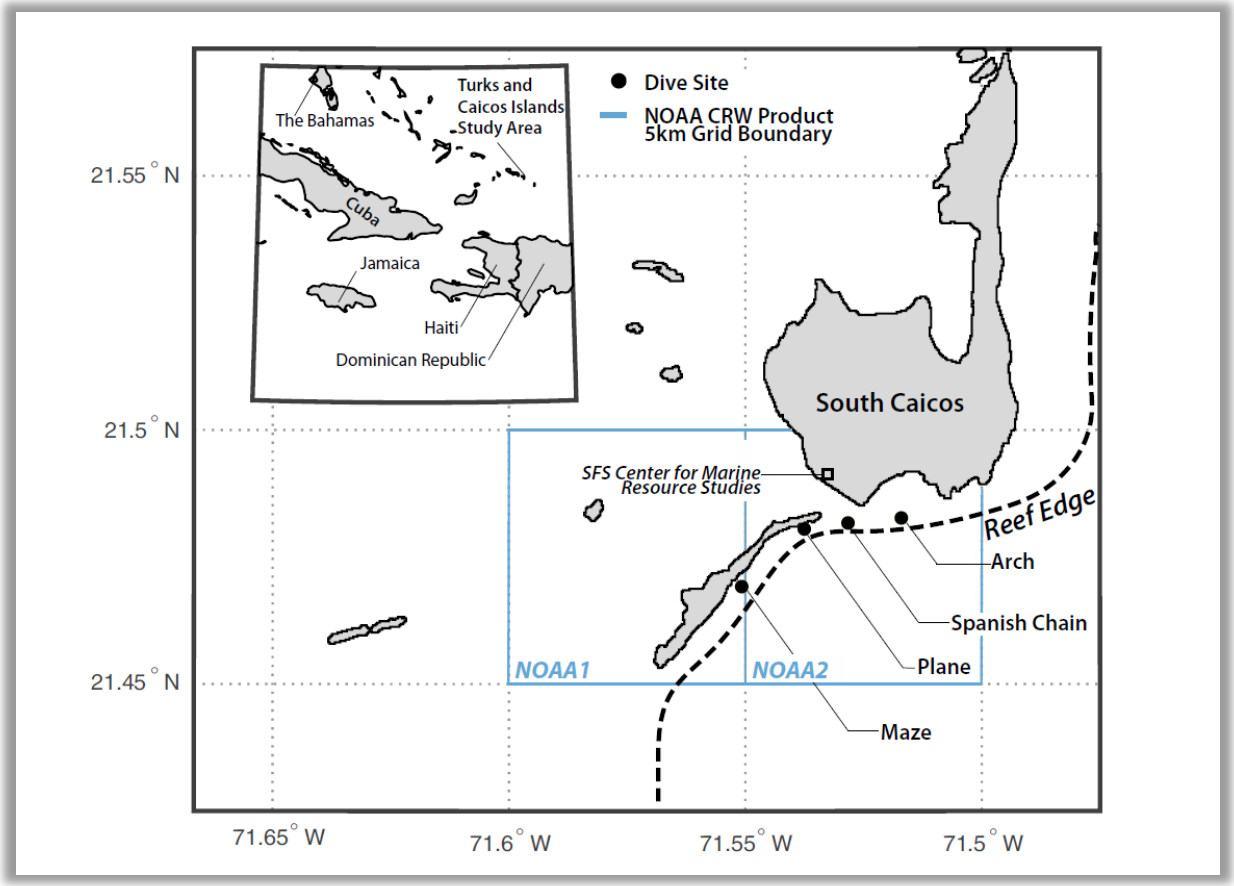


Figure 17 Coral reef distribution



Location of four Coral Reef Survey dive sites monitored by the students and staff at the School for Field Studies (SFS) Centre for Marine Resource Studies in the Turks and Caicos Islands

All coral taxa at the study sites were resilient to the maximum regional thermal stress during the 2014–2017 Global Bleaching Events GBE, with boulder-type corals showing no significant bleaching as a result of the peak thermal stress in late 2015 and plate-type corals responding with a significant ($p < 0.05$) bleaching signal (i.e., coral colour reductions), rebounding to pre-GBE pigmentations within months of the anomalously-high thermal stress (Knipp et al. 2020).

Sargassum

Inundations of sargassum are occurring on coastlines of the Caribbean including the Turks and Caicos Islands. Sargassum in the ocean is a key habitat for the survival of neonatal and juvenile sea turtles, when washed onto beaches it may serve to help prevent erosion, and transport nutrients to terrestrial ecosystems, which may further help prevent erosion by promoting the growth of sand stabilising plants. However, washed up sargassum may pose a threat to turtles on their nesting beaches, where it can act as a barrier to neonatal turtles as they struggle through the dense sargassum as they attempt to begin offshore migrations (Maurer, De Neef, and Stapleton 2015).

Furthermore, sites in the Mexican Caribbean saw decaying sargassum produce near-shore murky brown waters (van Tussenbroek et al. 2017), which effected the near-shore benthos by reducing light, oxygen and pH, resulting in eutrophication (van Tussenbroek et al. 2017). Near-shore seagrass meadows were replaced by algae, resulting in biomass loss, which could take years to recover or even become permanent, and near-shore corals suffered total or partial mortality (van Tussenbroek

et al. 2017). Which can also have an impact on tourism, a major contributor to the economy of Caribbean islands, including the TCI.

The most easterly islands, for example Grand Turk, are anecdotally reported to have the greatest quantity of sargassum deposited on the windward (east facing) beaches. However, most of the hotels are on the west so, with exception of some activity providers who use the beach and creeks on this side, the impact is minimal on the accommodation providers. There is limited tourist activity on South Caicos, located on the east side and has a brand image relating to the high standard and exclusivity of the island. Providenciales has by far the greatest number of tourist and real estate businesses, both expanding, and of great economic importance. These are spread over both sides the island, but the iconic Grace Bay is on the sheltered, leeward side, and Providenciales as a whole is sheltered from the worst of the influx by the other islands (Bartlett, Lee, and Myers 2019).

Figure 18 Prevailing wind direction from the east in the Turks and Caicos Islands (Bartlett, Lee, and Myers 2019)

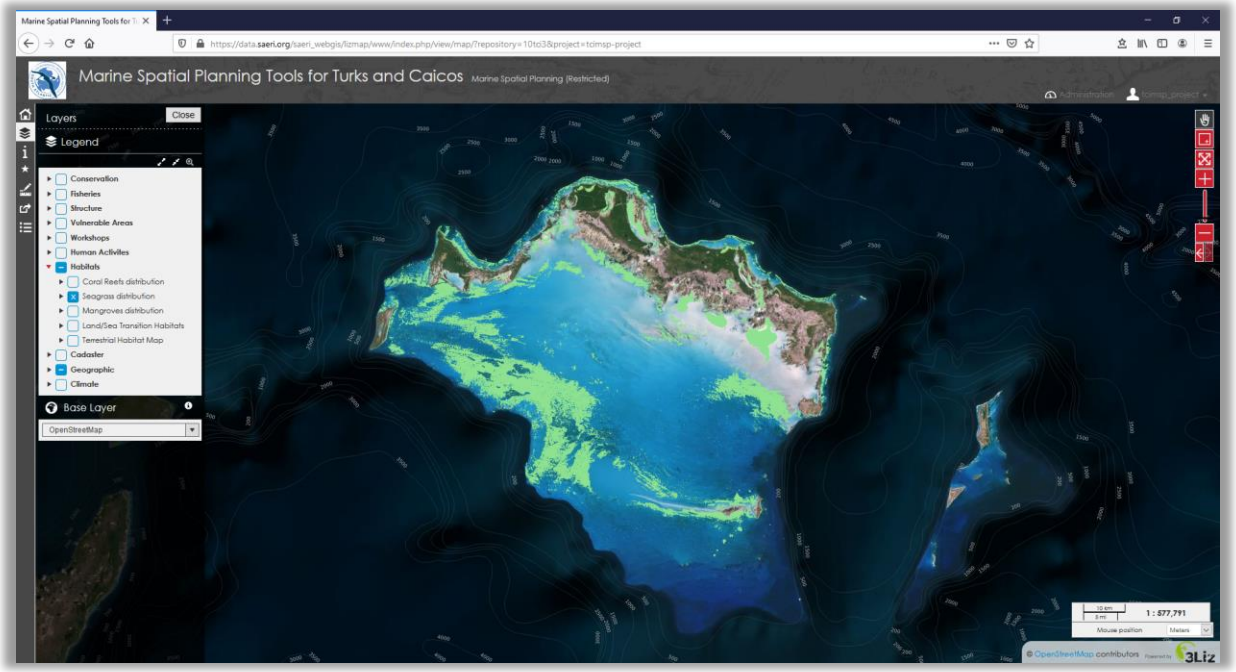


Figure 19 Seagrass distribution

Seagrass research in TCI has revealed that the tourism sector acts as one of the key stressors. Dredging for shipping channels, marinas and cruise liner ports are major problems, as are coastal developments, especially hotel construction. The use of chemicals for hotel landscape maintenance also causes run-off into the marine system. Other concerns relate to the clearance of near shore seagrasses to make way for what is perceived to be more idyllic sands; and the rise in the use of motor boats, whose anchors and propellers can damage seagrass beds (Baker et al. 2015).

Hurricane Ike. Particular sites of concern were those at the Leeward area of Providenciales that were patchy and of low density and subject to high disturbance from boat activity and dredging, East Bay on South Caicos, where seagrass meadows were extensively damaged by physical removal as a result of development and meadows in North Creek Grand Turk, where epiphytes covered at least 60% of leaf surface area (Baker et al. 2015).

Despite these concerns at some sites, the majority of visits identified healthy meadows with high density and extensive continuous distribution, exhibiting high % cover, low macroalgae, high water clarity and low epiphytic cover, particularly those within subtidal and deeper waters (Baker et al. 2015).

Given the impact of existing development on the health of the marine ecosystem and the continuing weaknesses in policy responses, the likelihood that future development will in turn result in further seagrass degradation is high. This points to the need to apply the precautionary principle, a principle central to international environmental governance regimes, including the CBD, to put in place effective conservations plans to protect again potential, future negative trends that pose threats to the remaining healthy seagrasses of TCI (Baker et al. 2015).

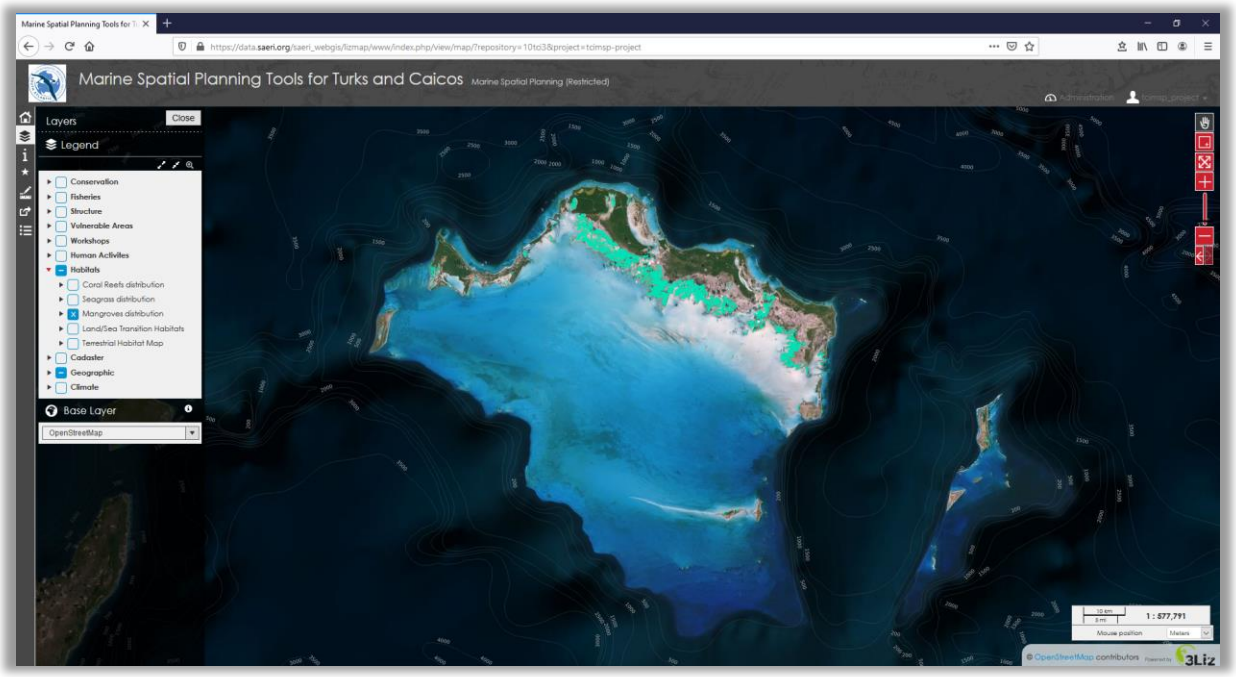


Figure 20 Mangrove distribution

Ecologically important areas for juvenile marine species such as sharks and fishes. Protect coast from storm surges.

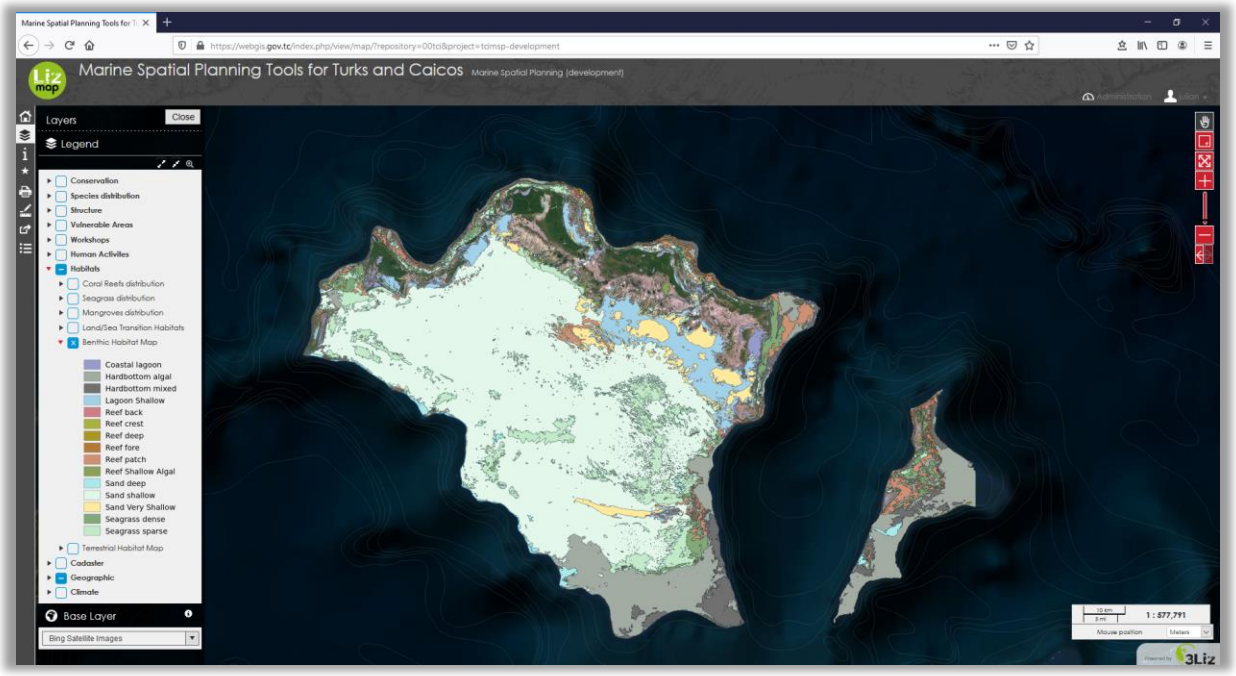


Figure 21 Benthic habitat around the Turks and Caicos Islands