Island Systems Management for Joined up Environmental Custodianship

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Abstract

Although data models for watersheds and marine environments exist, small island states such as BVI need environmental management that looks at the whole island system, from ridge to reef. No off the shelf package exists for the Island Systems Management, so BVI has developed its own, based around watersheds, outfalls and coastal units, which, while not perfect, helps identifies problems and stresses in the territory and is flexible enough to cope with varying data inputs. The system is now in place and is aiding decision makers in assessing both strategic and immediate response to carrying capacity, activity, surveillance and planning.

Introduction

The challenges of managing environments in small islands come from both the intricacy of the linkages from ridge to reef and to the shelf beyond, and the ability to achieve good management for small institutional and human capacity in governments' implementing agencies (Mills *et al*., 2001). Small Island Developing States (SIDS) in the Caribbean contain complex interlinked microenvironments, from rainforest and mountaintops, through deeply incised valleys with diverse vegetation complexes, aspects and water availability, down to small floodplains, narrow coastal plains and reclaimed land, some with mangrove and salt pond systems. On the water side, too, beyond palm fringed sandy beaches there can be seagrass and macroalgae beds, coral patches, reef structures and soft coral gardens extending out to the shelf. Interacting with these natural resources, various natural and human activities are occurring, fish are cycling through the water from nursery to adult habitats, people are living, working and recreating within the system, and imposing a built environment on the natural tapestry.

To conduct effective environmental management in this complex situation, any system must look holistically at the resources available, the activities played out on them and their potential (vulnerability) and actual impact on those resources. Many international agencies and scientists have worked on concepts of Integrated Coastal Area Management (UNEP, 1996), Integrated Coastal Zone Management (Clark, 1992) and legislation for managing such (Boelaert-Suominen & Cullinan, 1994). There have been regional models run by organisations to look at the threats to single resources, such as reef (Bryant et al, 1998) from World Resources Institute (WRI) but using coarse resolution meant small islands were excluded or oversimplified (Jon Maidens, *pers. comm.*). A few even talk of managing the whole island system (UNESCO, 1994, Chase & Nichols, 1998). While the theoretical concept is clear and its need accepted, the mechanism for achieving good management still has to be developed. A number of case studies focusing thematically or on a single watershed or marine unit exist, showing that management can enhance the environment (e.g. UNEP, 1999), but there are few comprehensive and routinely manageable information systems available to small island governments to allow for evaluating the entire physical system, any problems which exist within it, and monitoring and evaluating human interventions and their effects.

A spatial structure and well-defined information flows are vital for this to be achieved. ESRI have recently created data models that can be used for the Marine (Wright *et al.*, 2003), Estuarine and Watershed environments, but none of these truly look at the whole system at a scale and integrity that meets the requirements of small islands. Sophisticated modelling of environments might be the dream of Geographical Information Systems (GIS) experts, and in certain aspects of biodiversity and ecology have been tried (e.g. ECOPATH; FAO, 2002) but neither the data are available for either a complete resource assessment or for timely monitoring, nor is the technical manpower available to keep that system functioning. A simpler system is required for SIDS that can be updated and is flexible enough to cope with different levels of information, of varying quality, without jeopardizing system functionality. GIS still provides the framework for creating and storing datasets from disparate sources and a suitable toolbox providing synthesis and analysis. The only parallel to the system described below is in the US Virgin Islands (Battelle, 2003), where division of waterbody assessment units (AU's) has recently been completed to aid non-point source pollution monitoring and enforcement. The ISM framework proposed here takes this further and is seen as a generic framework for many types of environmental monitoring, including pollution and sedimentation but also resource assessment, risk assessment, fisheries and research. It has also been achieved completely by British Virgin Islands (BVI) Government agencies and without the larger federal resources available to the USVI.

British Virgin Islands and its environment

The British Virgin Islands are a series of 60 islands 100 km east of Puerto Rico in the northeastern Caribbean (Fig. 1). The total land area is 151 km^2 and the Exclusive Economic Zone (EEZ) extends for an area of 86,000 km^2. It is part of a shelf that includes the US Virgin Islands (USVI) and Puerto Rico. Of a total population around 21,000 (BVI Development Planning Unit, 2000), around 14,000 live on the largest island, Tortola, 20 km long and 3 km at widest. Virgin Gorda, Jost Van Dyke and Anegada and about 12 other smaller islands have residential populations; the rest are uninhabited. The population is rising and development of buildings, new tourism facilities to cater for land based, cruise ship and yachting industries (Fig. 2) and offices has been accelerating, with associated access road building and land clearances.

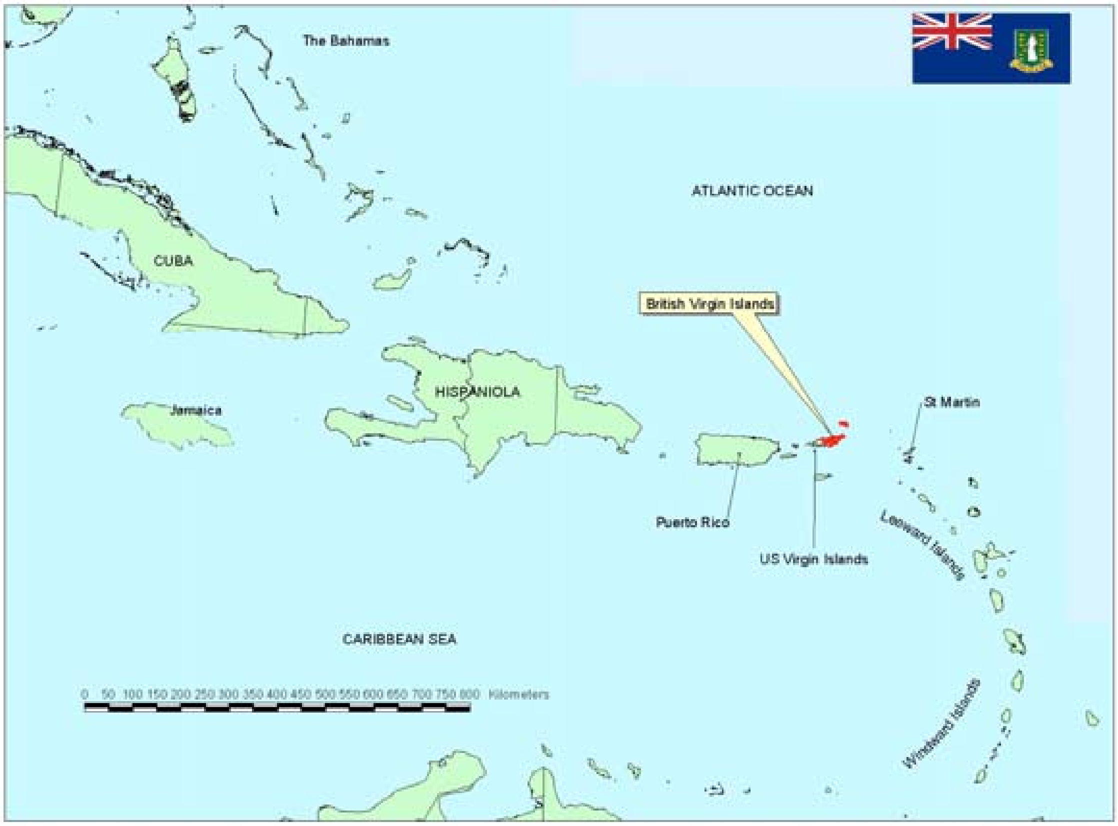

Fig 1. Location of the British Virgin Islands in the north eastern Caribbean.

Fig. 2 - Yachting and cruise ship industry are two of the major tourism activities in the marine side, and interact with fishing, navigation, local recreation, diving and research activities.

The Environment of the BVI is very special. Although it was heavily farmed with cotton and sugar plantations in the 18th and 19th Century, the collapse of this industry following emancipation led to a regrowth of secondary shrub. In some places, around temporary watercourses (called ghuts) and cliff edges, some original vegetation remains, especially the mangrove stands and salt ponds around the coast. There are many important floral species present and several endemic faunal species, including the smallest species of lizard in the world, the Virgin Gorda Gecko (*Sphaerodactylus parthenopian*) and the endemic Anegada rock iguana (*Cyclura pinguis*). The largest colony of frigate birds (*Fregata magnificens*) in the eastern Caribbean exists on one island, and many bird species are resident, pass through or breed around the islands. On the marine side, the BVI has the best preserved coral reefs of the eastern Caribbean, including the Horseshoe Reef around Anegada, the third largest in the world. Seagrass beds and sands also provide habitat for massive fish stocks, largely unexploited, and lobster and conch beds exist, as do important feeding grounds for some (Fig. 3), and a re-emerging egg-laying site for the leatherback turtle (*Dermohlelys coriacea*).

Fig. 3. The coral island of Anegada contains massive reef and seagrass beds that harbour diverse habitats for a range of locally and internationally important species, such as this Hawksbill Turtle (*Eretmochelys imbricata*)

Anecdotal evidence shows where serious environmental threats are damaging this unique assemblage. Untreated sewage is discharged in bays surrounded by heavy population. Poor design and bad construction practices for roads and dwellings have caused serious erosion problems during periodic heavy rainstorms, and the sediment is stifling coral inshore (Fig. 4). Sand mining and development around beaches cause erosion of beachfronts, which put coastal properties at risk.

Fig. 4. Sediment plumes smother coral reefs off Tortola after a heavy rain event. Although a natural process, the amount of sediment is increased significantly by environmentally insensitive road cutting and housing development (Andrew Moody).

Anecdotal evidence is not enough to understand the extent and mechanism of island systems, or educate both the general public and key decision makers. Neither are aggregated statistics that mask the subtle spatial variation in the problems. A geographical framework is needed to divide the environment into management units, and a system which understands how processes flow through those units and interlink with one another. Following this, a resource assessment can identify the characteristics of each unit, and give an indication of vulnerability of an area and its contents to environmental problems. Finally, with a coordinated monitoring programme studying critical factors, one can look for changes in the system and hopefully pre-empt any potential failure.

Establishing a framework

To be able to compare different sites, aggregate and summarize information, the environment needs to be separated up into discrete management units. This has been done for small sections of countries (e.g. the Soufrière Marine Management Areas (SMMA) in St Lucia (SMMA, 2003)), but until recently not on the territory wide scale that is being advocated here (USVI (Battelle, 2003)). While there are few problems with dividing the terrestrial environment into watershed areas with hard polygon boundaries, polygon division of the marine environment is more controversial. The ocean currents and tides means the environment is much more volatile than the terrestrial one, and the canyons and ridges in the substrate are not necessarily natural barriers to movement. However, in a practical management sense, these areas have to be delimited.

In determining watersheds, areas were defined by the direction water moves once rain has fallen on the shed. The outlet of each subcatchment will be where one ghut meets another, or empties in the sea. At the point where they empty into the sea, this defines the outfall of the supercatchment. Most of the water that has fallen in the watershed above, that does not evapotranspirate or is extracted for human consumption, will end up here and will transport sediment and other pollution into the sea.

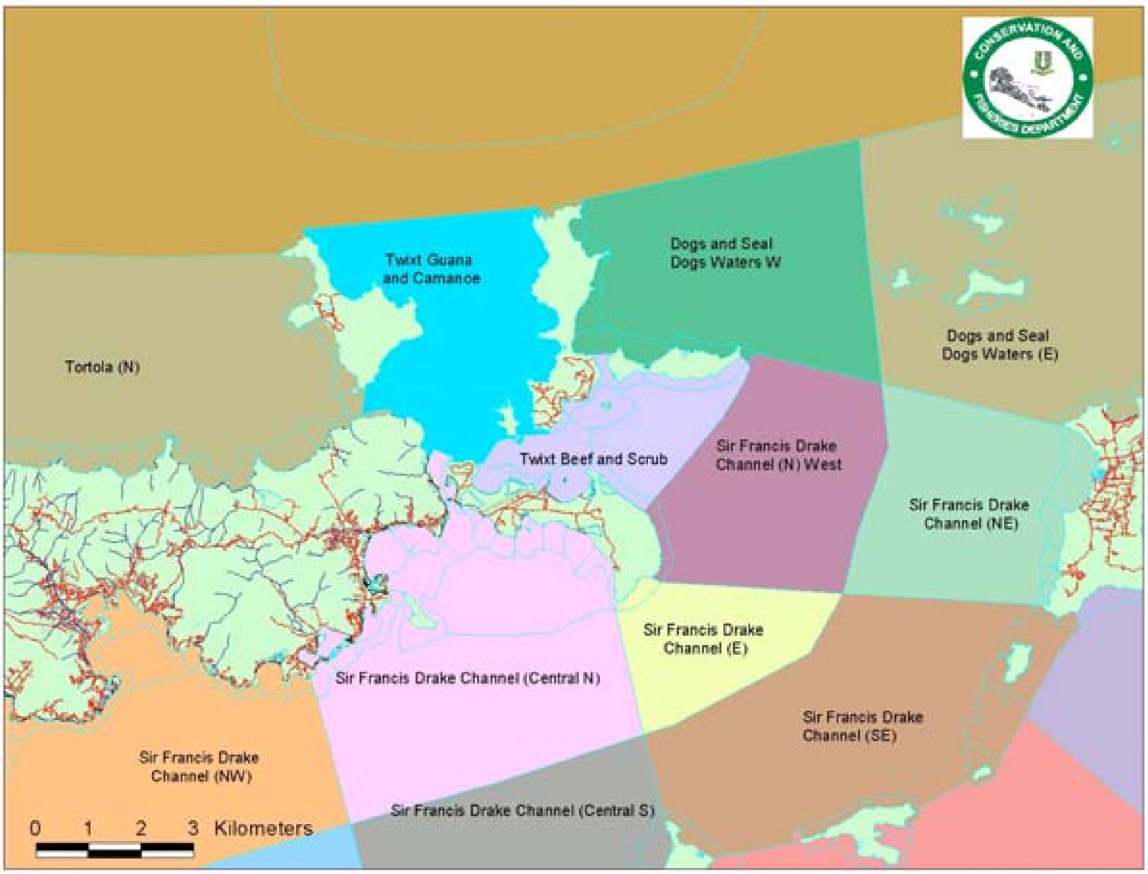

Fig. 5. Third level aggregation of units showing details of second and first level units in embayments.

With marine units, a combination of choosing homogenous units of substrate and topography/water depth in conjunction with the coastline morphology was used to determine where boundaries should lie. Land based pollution sources predominantly impact embayments (Battelle, 2003); meaningful positioning of a boundary between nearshore and inshore waters is important. Embayments were demarcated by extreme headland but rather than drawing straight lines between these features, the edge of a fringing reef, a large patch of seagrass, or where water has passed a certain depth were used as determinants, since they form the barrier which restricts flushing and physical, chemical and biological characteristics differ on either side. All inshore waters were also demarcated, including channels between islands and the outer waters to the shelf and the limit of the EEZ. The units became larger further out, as it was seen that management of near inshore waters is far more critical at this time, especially in its interaction with the landward environment. A nested hierarchy was used to create four levels of aggregation. The smallest denoted relatively discrete areas, such as small bays. The second level combines these to show major embayments (such as Road Harbour, made up of four smaller bays). The third level joins those bays with larger bodies of water, and the fourth level looked at macro units made up of major channels or divisions around the shelf (Fig. 5).

The linkage between different catchments and the sea is made by defining where ghuts and sewage outfall. Either concentrations of pollution and sediment will be transported by the ghut, and discharged into the bay at the ghut outfall, or manmade outfalls discharge waste directly into the sea. These locations are thus critical points in the island system. Outfalls were mapped and characterised in terms of size, the material they flow over (sand or boulder), any human interference (concrete lining, a bridge), and identifying any blockages. The outfalls are linked with their parent watersheds by name and the locations of outfalls in the marine units means that by using tabular and spatial joins, data from the watershed can be aggregated to show the relationship with features in the coastal zone (Fig. 6).

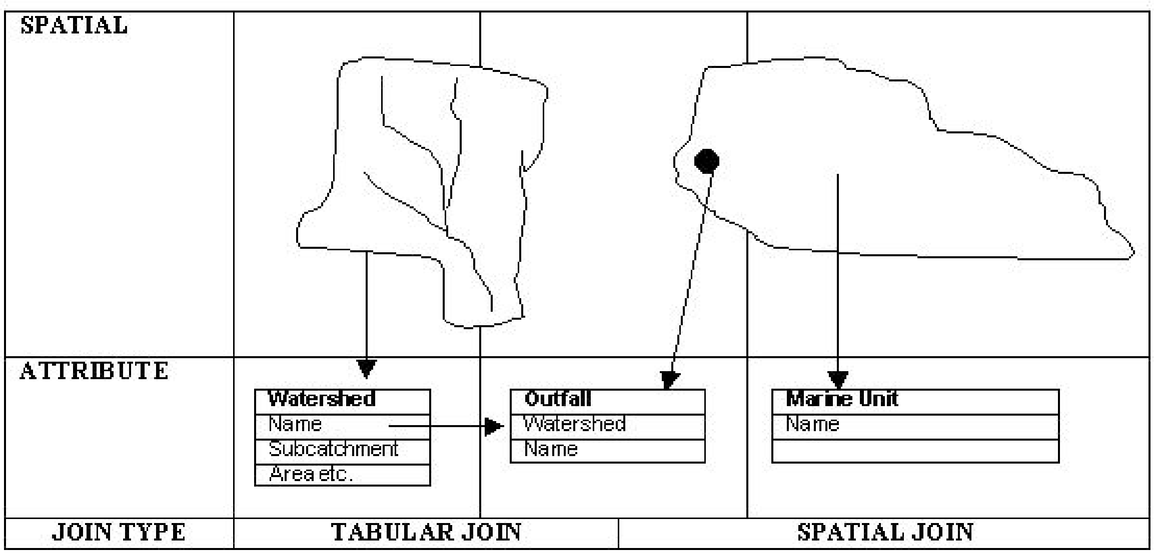

Fig. 6. Schematic showing major framework units and the relationships between them.

Characterising watersheds and bays

A watershed's natural and human characteristics, its shape, size, physical features, roads, buildings and activity determine the degree it is more or less vulnerable to erosion or providing pollution impact. Additionally, on the marine side, the shape and size, habitat, ability to flush (i.e. its current and tidal movements) need to be characterized to determine the potential impact on embayments and outer units. Table 1 shows the current list of parameters that are being used to characterise watersheds and marine units.

Watershed	Marine Unit
Area of the watershed	Size of the area
Slope – calculated by contours and classified into 8 grades of slope	Area of coral reef
Length of ghuts and profiling characteristics	Area of seagrass beds
Vegetation types	Area of other terruginous or coral rocks or rubble
Number/Area of buildings	Sanded area
Length of roads	Proportions of depth ranges
Length of roads with bare, exposed soil	Current flows to establish the flushing characteristics
Length of mangroves along the coast	Location of desalination intakes
Area of mangroves	Location of sewage outfalls
Soil and geology	Tidal ranges
Salt ponds and mangrove swamps extent	
Beachfront Length	
Hazardous materials location	

Table 1. Current watershed and marine unit characterisation criteria. Not all these layers are available in the GIS at present for all locations.

Monitoring and Critical Indicators

As well as understanding the character of watersheds and marine units, it is essential to monitor trends in environmental health. While this can only be achieved by a considerable history of data collection, the establishment of meaningful, synchronized monitoring programmes is essential. They must be feasible both logistically, in tune with personnel and technical resources, and repeatable in a controlled manner.

To accomplish this, the Conservation and Fisheries Department (CFD) has careful chosen study sites based on a balance of a variety of natural habitat complexes, the levels of activity in the bay, and a geographical spread of sites (Fig. 7 and Table 2). In addition permanent monitoring sites, events such as oil spills or the approval for development (e.g. reclamation, house and road building, jetty construction, mooring implementation) will be tracked (Table 2).

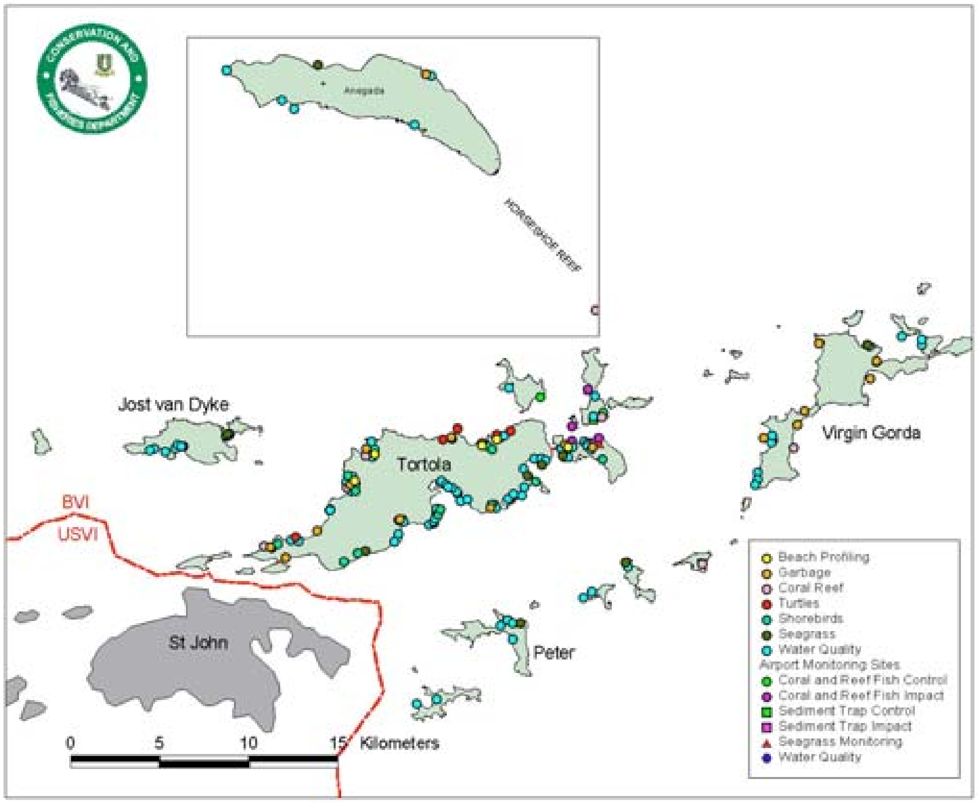

Fig. 7. Distribution of current and near-future monitoring sites for BVI. Some are to reflect specific projects (e.g. the airport expansion), some for specific issues and others to produce an assemblage of data to monitor Island System Management requirements.

Monitoring Programme	**Attributes to be documented**
Fixed monitoring Sites	
Beach Profiling	Angle and beach width
Garbage	Quantity, types, flotsam and jetsam surveys
Water Quality	Coliform, faecal coliform, temperature, salinity, dissolved oxygen, Ecoli, Nitrates, nitrites, phosphates.
Coral reef monitoring	% coral cover, species abundance, health, algal growth.
Seagrass monitoring	Density, algal growth
Sediment traps	weight, composition
Mangrove health	Litter, leaf litter, general health, extent, disturbance.
Salt pond	Litter, chemical composition, water depth.
Shorebirds	Numbers, activity, species.
Event monitoring	
New road cuts	Date of cut, length.
Development applications	Date of application, nature, area.
Pollution events.	Date, nature, extent, dispersal.
Turtle Monitoring	Date, occurrence, species, activity (nesting, foraging etc).
Fishkills and other faunal surveillance	Date, time, extent, nature.

Table 2. Fixed location monitoring and event monitoring datasets. The number and nature of these will change according to priority setting by all environmental agencies. Some of these still need to be implemented.

There will also be some review of historical patterns; in particular looking at clearance of protecting vegetation (e.g. removal of mangrove stands, and infilling of salt ponds). Finally, although this system is looking at ongoing environmental threats from non-point pollution sources or from individual small-scale results, it can be used for other purposes; in terms of fisheries, surveillance and vulnerability to natural disasters.

Identifying vulnerable areas and vulnerability

The protection of the entire environment remains a major goal of this project, but in reality, you can only prioritise your resources on certain key areas. There are layers within the GIS that show the existing protected zones, and for certain themes, the vulnerability of the whole environment to them (Table 3).

Landward	Marine
Designated artificial zones	
Protected watersheds for water collection	Natural resources, especially important coral reefs (e.g. tourist snorkel trails and dive sites), fishing protected areas, marine protected areas and dive sites.
National Parks and other important cultural, tourist, or recreation sites	Fishing priority areas (areas where certain fishery activities are allowed to occur due to nature of practice or fishery importance of such as an important baiting ground, or spawning site.
Recreational Beaches	Water intakes for Desalination or cooling systems
Important wildlife sites, nesting, feeding and breeding (for example turtle beaches).	Marina and jetty areas, where people interact with the water significantly
Coastline protection areas and hurricane shelters (e.g. for yachting industry) – mangrove swamps, salt ponds and other roads.	
Critical facilities (administration, police, fire service)	
Vulnerability layers	
Natural Hazard zones – storm surge, liquefaction potential, high velocity wind zones	Vulnerability of coastline, salt ponds, mangrove swamps, ecologically important areas (breeding, roosting and feeding sites) and socio-economic areas to pollution (especially oil spills). *

Table 3. Defining vulnerability and identifying those zones that should be specially protected on landward and marine sides. *NOAA conducted a survey of the Environmentally Sensitive Areas along the coastline and wetlands of BVI as part of a Puerto Rico and Virgin Islands wide study in 1999 (NOAA, 2000).

Analysis

The foregoing sets up the framework and the layers needed to characterise, monitor and identify special zones for protection. To bring this together into a coherent series of statistics and maps need several processes of analysis. The decision makers can choose to come in at any level to use the results. The following techniques can be used on any of the layers defined above (the thematic, monitoring or vulnerable areas) separately and in combination.

Visualisation – At either the individual layer level or a composed map, simple visualisation of information is still an incredibly powerful tool for decision makers.

Quantification – Calculation of areas, or visualising information from monitoring databases as graduated symbols or colours, or even ranking of data provides the next level of interaction.

Cross Tabulation – The key to Island Systems Management GIS is the ability to take layers of thematic information and calculate aggregated statistics for individual management units (watersheds and marine units). Nesting of sub-catchments within catchments, and of embayments within onshore, offshore and major marine units allows for aggregation at a series of scales (Fig. 8). Using pivot tables in Microsoft Excel, these operations can become routine and semi-automatic (Fig. 9). All the GIS layers can be used in this way to show the quantification of, say, number of buildings, area of slope categories, or length of unpaved roads, in a watershed. Similarly, the area of coral reef, the length of beach, the average coliform value, the total turtles nesting, can be aggregated for marine units.

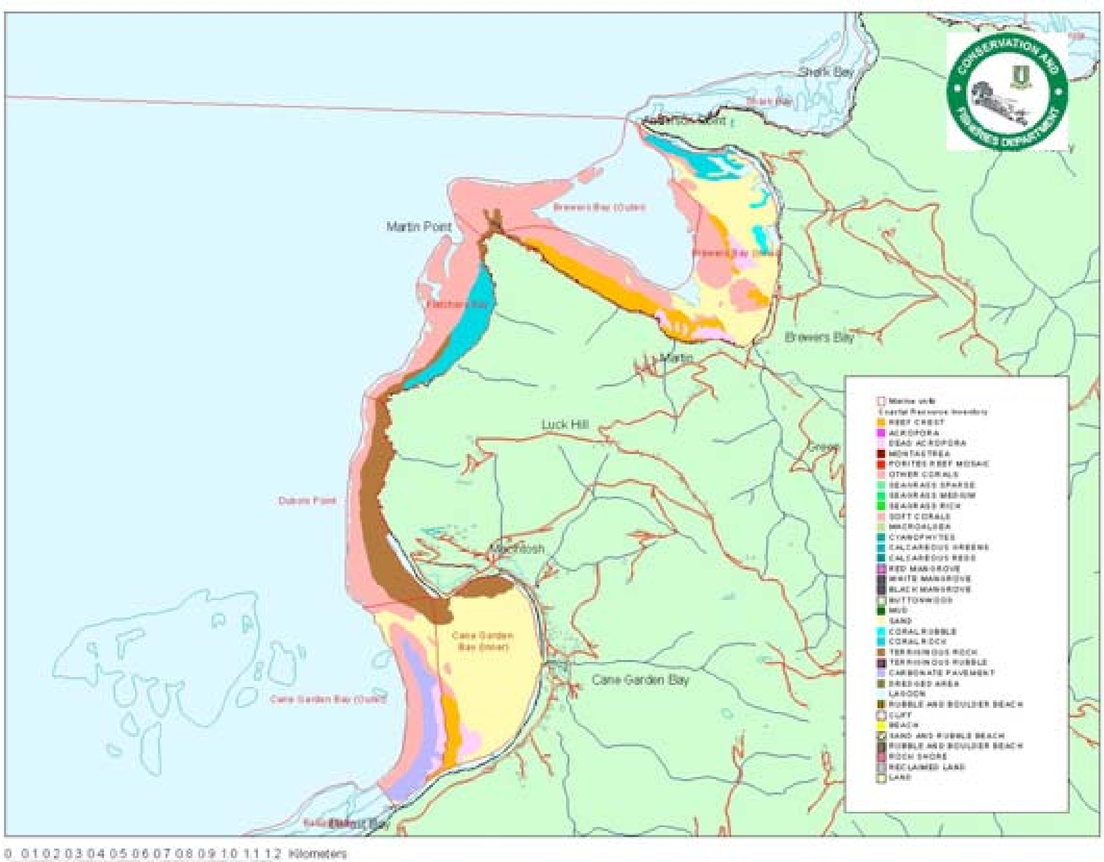

Fig 8. Resultant analytical layer of information for coastal resources

TOTAL AREA in m^2	RESOURCE											
FIRST ORDER MARINE UNIT	CARBONATE PAVEMENT	CORAL ROCK	CORAL RUBBLE	DEAD ACROPORA	MACROALGAE	OTHER CORALS	REEF CREST	RUBBLE AND BOULDER BEACH	SAND	SOFT CORALS	TERRIGINOUS ROCK	**Grand Total**
Ballast Bay	34064			5384					7320	41640	20867	**109276**
Brewers Bay (Inner)		25980	8054	24902	14263	95385	75291	5287	162000	37644	3080	**451885**
Brewers Bay (Outer)						19694			6	85789	6925	**112415**
Cane Garden Bay (Inner)	97			12795			21687		252121	4899	26655	**318253**
Cane Garden Bay (Outer)	54149			16058			43		26304	68568	8936	**174057**
Dubois Point										61673	98549	**160222**
Fletchers Bay		58045						404		100580	14528	**173558**
Larmer's Bay		1836								132822		**134658**
Grand Total	**88309**	**85861**	**8054**	**59140**	**14263**	**115080**	**97021**	**5691**	**447751**	**533616**	**179540**	**1634325**

Table 4. Sample cross tabulation of marine units and coastal resources.

Cross-comparing - By using the mechanism in Fig. 6, data aggregated from the watershed can be transferred to the marine unit by way of the outfall. Information can be tabulated together within the marine unit showing the impact from the watershed. Cross comparisons of watershed characteristics or activity can then be made with water quality or resource health in the marine unit.

Indices –Aggregated data in a spatial context can be misleading as it does not take into account characteristics of the spatial unit, in particular its size. This leads to a masking of the true impact on a small bay over a large bay, for example. They also do not necessarily show whether phenomena need to be compared in a linear or alternative way (e.g. logarithmetically). The creation of indices for different parameters will help to normalise the data so that comparison across different watersheds or marine units can be made. The most effective normalisation will be by dividing any statistic by the area of the unit.

Thresholds – The establishment of maximum and minimum thresholds for environmental factors (such as Total Maximum Daily Loads (TMDL) for water pollution (Battelle, 2003)) will allow flags to be sent to the system on an individual layer basis to show where issues need addressing. In addition, it may be possible to start looking quantitatively at the notion of a carrying capacity and calculate for each marine unit how close the unit is to reaching it. The topics for investigation will be number of moorings, yacht anchorage capacity, number of tourists on beaches, number of houses in watersheds. Quantitatively assessing carrying capacity is notoriously difficult but a sliding scale might be a useful concept to take forward; if erosion and sediment control, sewage facilities, careful planning and buffer zones are put in place, then a larger capacity can be promoted than where poor environmental management procedures exist.

Critical Indicators – Taking the thresholds argument one step further, we can determine which of the monitoring tools we are using are critical indicators of the health of the environment. By showing how many of these indicators have passed their threshold, we can determine both the general health of an individual bay and, using the monitoring databases where available, show whether the unit is deteriorating or improving. Depending on research from scientific papers or brainstorming exercises by the environmental agencies, it may be possible to weight the criteria used to decide what are the most important for establishing environmental health.

Simplified presentation – Coming full circle, the critical indicators listed above can be presented to decision makers as simple maps, showing either the number (or the sum of weightings) of the critical indicators, or a simple ranked map that shows areas "Severe", "Stressed", "Slightly stressed", "Satisfactory", "Pristine". Without demeaning decision makers' intelligence, this may be all they have time to take in, although systems would ensure that the trail back to original raw data layers could be mapped if necessary.

Advantages and limitations of ISM GIS

There are numerous benefits for technicians, public and decision makers of having carefully defined marine and watershed boundaries. Firstly it accurately describes areas, where in the past there has been the confusion when considering placenames, locations and boundaries. Second, it allows users to quantitatively compare between physical parameters and changes in and between predefined areas. Third, data from disparate sources can for the first time be looked at together, and summarized in such a way that the decision maker (head of department, permanent secretary or minister) can be given information in a palatable format, as a simplified chart, a summary table or best of all, a map depicting problem areas. It also allows us to demonstrably link the land and the sea which is so crucial in the Island Systems Management concept.

There is a need to strengthen the concepts in ISM and understanding the linkages. E.g. it is not just an in-situ spatial phenomenon, and although it adequately describes watershed/coastal interaction, it does not yet deal with downchannel currents, dispersal rates and other interactions. Using better science is necessary but CFD will be able to do little of this for itself. It is up to the wider scientific community to produce the theories and transmit the methodologies to government agencies in a palatable format. Many training workshops, manuals and literature are not getting to key personnel in environmental agencies in small islands; it is not available, there is no time to digest every nuance, and once completed, training and workshop conclusions are left on the shelf and there is not the help to implement amongst the large number of other duties government personnel have to do. The environment department (CFD) in BVI is small and overstretched with remits to conduct research, development, management, legislation and enforcement of all fisheries and conservation matters in the territory. It cannot hope to do everything for itself and needs outside assistance especially in conceptualisation.

While the system is not perfect, may have faults in its scientific reasoning and is not the optimal management solution either, it is manageable within the resources of the country. Rather than wait for the perfect system to be dropped at our doors, the BVI needed to take the first steps now to create the framework and shall improve the ISM model through further iterations. When those iterations occur, these are some of the issues that will need addressing:

- A tightening up of the mapping of watersheds and their linkage with marine units, to ensure we have a clear picture of where impacts are occurring.
- A review of the monitoring techniques, how data are gathered and the costs.
- A review of how to weight critical indicators.
- Conceptualisation and measurement of water flows in the marine areas.
- A better handle on the use of roads as water drainage channels, and their hydrology in terms of storage and ocean discharge.

The ISM concept is helping CFD readjust its office working. Not only has a culture of data collection and utilisation been re-implemented into the department, but also better field work planning is occurring. For example, in capturing information on the outlying islands field teams are often heading out to complete three or four monitoring tasks in one trip, and share roles and responsibilities in the field team. No staff can be a complete specialist; all have to multitask. The locating of specific monitoring stations and intra-departmental information sharing is improving inter-unit field planning.

While a larger monitoring programme, and detailed satellite and mapping data would be better, it is more appropriate to keep the project scale at this level. BVI does not have the funds for so much data, and can only afford to update its basemaps at best once every ten years. However, there should be no fear of using sub-optimal data; we have to make best use of what we have, and as long as we document and appreciate data quality, then it is better than a knowledge based on anecdotes and feelings (Mills, 2000). Even surrogate use where appropriate datasets do not exist is acceptable, given due consideration.

At the data collection stage, for monitoring programmes in particular, and during analysis, a number of levels exist to give flexibility to the resource levels, time available and technical competence of staff. Decisions can be made at rudimentary visualisation level, although more considered and more quantitative decisions can be made at the critical indicator level if circumstances allow. This flexibility is essential for the changing resource levels in the department.

The matrix for determining how the large number of factors can be distilled to critical indicators still needs to be researched and discussed among the environmental agencies in the BVI. But this paper shows that both the spatial and the conceptual framework now exists. The ISM GIS helps people to start to understand geographically about the holistic nature of their islands and the linkages within the environment, which is essential if we are to fix the problems. For example, blaming the trashing of coral reefs purely on tourists and yacht waste dumping is narrow minded, much of the threat comes from landward sources; domestic sewage and sedimentation in particular.

Conclusions

The model being advocated here could be of use to other SIDS, and adapted to involve whatever parameters seen as important. In BVI there is little commercial agriculture, but especially in the Windward Islands and elsewhere, many small islands depend heavily on monocultures with high inputs that pollute water channels. In other areas, industrial development will be more significant. Two principles are applicable whatever the specific needs of individual SIDS. First, linking and monitoring land and sea within the whole island system is critical. Second, the conceptual model has a sliding scale of sophistication, so is flexible for SIDS to enter at whatever level, and adjust based on available human and institutional resources.

The fact the model may not have the correct parameters to help BVI at present, or that BVI does not have the means to collect all information necessary, does not detract from the idea that Island Systems Management through GIS is essential. The framework being produced is very flexible and allows for people to prioritise within BVI's science, human and technical resource constraints. Too often, glorious studies are done of a country or region by outside help, and this can be repeated by these agencies over periods of time. But the host country cannot sustain the effort, so data from one study to the next may not be compatible, and no true picture of change is built up. This process tries to build capacity from within the country, and assists in profiling environmental management to decision makers as a coherent system. Hopefully it can start to generate new funds to expand the programme and put the environment at the centre of island life, as the particularly limited but incredible resources in islands such as BVI can be properly understood and conserved in perpetuity. BVI is in a rare position in the Caribbean in that it has significant tracts of beautiful, diverse and pristine environments. With proper information and good management, we can help to conserve these.

On top of the challenges of dealing with the environment, for a SIDS government to be able to both build and maintain an information system is a significant undertaking. The Island Systems Management (ISM) GIS will be seen as an attempt to move the BVI into a new age of environmental monitoring, while appreciating the institutional capacities and specific requirements of a system for small islands such as the BVI archipelago.

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