GIS in Fisheries Management in the British Virgin Islands: Issues and Practicalities

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ABSTRACT
Geographical Information Systems (GIS) have matured in the past ten years with easy-to-use windows-based graphical user interfaces, a wide range of tools for managing input, storage, retrieval, display and analysis of data, and a larger number of users with significant conceptual and practical experience in GIS. GIS allows for analysis of spatial problems that no other technology can handle. Despite great potential for use in marine studies, much GIS application remains land based. Fisheries management could benefit from its application in resources assessment (habitat mapping), scientific studies (biomass, biodiversity indices), project and management plans (formulating stratified sampling or establishing Fisheries Protected Areas) surveillance, resource allocation (calculating catch or surveillance effort), and trend analysis (looking at spatial patterns of fish abundance or catch over time). Its slow take up in fisheries management stems from complex conceptual problems in marine areas (handling of fluid, 3-D situations) a lack of data and human resources with limited specialist knowledge to handle the technology.

GIS is an integral tool of government in British Virgin Islands (BVI) and its use in fisheries applications has ranged from coastal resource mapping, fish catch distribution to a surveillance network. However, wide-ranging use of GIS in BVI is constrained by the small size of islands and the lack of specialized human resources in combining GIS and fisheries expertise. BVI stakeholders work around these issues by sharing resources, making best use of available data and collaborating with regional and international institutions to avoid reinventing the wheel. New data sources, at suitable scales, from international websites or from better and cheaper access to satellite data will also improve the management of fishery resource in small island states like BVI.

KEY WORDS: GIS, marine studies, fisheries management, small island states

El Uso de Sistemas de Información Geográfica en el Manejo de las Pesquerías en las Islas Virgenes Británicas BVI

Los Sistemas de Información Geográfica (SIG) han madurado a lo largo de los últimos diez años desarrollando gráficos fáciles de usar, basado en Windows, un amplio rango de herramientas para manejar entrada, almacena-
miento, recuperación, despliegue y análisis de datos, y un gran número de usuarios con significativa experiencia conceptual y práctica en SIG. SIG permite el análisis de problemas espaciales que ninguna otra tecnología puede manejar. A pesar de su gran potencial para su uso en estudios marinos, muchas de las aplicaciones del SIG permanecen en tierra. El manejo de las pesquerías se podría ver beneficiada de sus aplicaciones en la evaluación de los recursos (mapas de hábitat), estudios científicos (biomas, biodiversidad, índices), proyectos y planes de manejo (formulando muestreos estratificados o estableciendo Áreas Protegidas de Pesca) vigilancia, (calculando esfuerzos de pesca y vigilancia) y análisis de tendencias (observando los patrones espaciales de abundancia o captura en el tiempo). Su lenta incorporación en el manejo de las pesquerías proviene de complejos problemas conceptuales en áreas marinas (manejo de fluidos, situaciones en 3D) falta de datos y recursos humanos con un limitado conocimiento especializado para el manejo de la tecnología. SIG es una herramienta integral de gobierno en las IVB y su uso en aplicaciones pesqueras ha variado desde el mapeo de recursos costeros, distribución de capturas hasta una red de vigilancia. Sin embargo, un amplio rango de uso de SIG en IVB esta restringido por el tamaño tan pequeño de las Islas y la falta de recursos humanos especializados que combinen conocimientos de SIG y pesquerías. Los tomadores de decisiones de las IVB trabajan alrededor de estos temas al compartir recursos, haciendo buen uso de los datos existentes y colaborando con instituciones regionales e internacionales para evitar reinventar la rueda. Nuevas fuentes de datos, a escalas adecuadas, de sitios de Internet internacionales o de acceso de datos mejores y más económicos de satélite mejorarán también el manejo de los recursos pesqueros en Estados pequeños como las Islas Vírgenes Británicas.

PALABRAS CLAVES: SIG, estudios marinos, manejo de pesquerías, estados de las islas pequeñas

INTRODUCTION

Effective management of fisheries in small island states needs to include analysis in both spatial and temporal dimensions. Fisheries in the Caribbean are generally heavily exploited, especially because of high population densities, limited employment opportunities, and relatively small island shelves. Coral reef fisheries are most vulnerable to overexploitation, because reefs are often near to the shore, and easily accessible to fishers with small crafts. Tropical fisheries are all multi-species and multi-gear, in which a large variety of fish and invertebrate species are taken by a variety of fishing gears. In Caribbean fisheries progressive changes in catch composition have been documented, with catches of the most valuable larger predatory species becoming a smaller percentage of total landings. The larger predators will take hooks, enter traps, be caught in nets, and generally be easier targets than smaller herbivores. In addition species that aggregate during spawning, such as groupers and snappers, are vulnerable to over-harvesting at these times and places (Garcia-Moliner 1985, Colin et al. 1987, Sadovy et al. 1994). Over-harvesting of the most vulnerable species can lead to local extinction of smaller herbivores. In addition species that aggregate during spawning, such as groupers and snappers, are vulnerable to over-harvesting at these times and places (Garcia-Moliner 1985, Colin et al. 1987, Sadovy et al. 1994). Over-harvesting of the most vulnerable species can lead to local extinction of smaller herbivores. In addition species that aggregate during spawning, such as groupers and snappers, are vulnerable to over-harvesting at these times and places (Garcia-Moliner 1985, Colin et al. 1987, Sadovy et al. 1994). Over-harvesting of the most vulnerable species can lead to local extinction of smaller herbivores. In addition species that aggregate during spawning, such as groupers and snappers, are vulnerable to over-harvesting at these times and places (Garcia-Moliner 1985, Colin et al. 1987, Sadovy et al. 1994). Over-harvesting of the most vulnerable species can lead to local extinction of smaller herbivores. In addition species that aggregate during spawning, such as groupers and snappers, are vulnerable to over-harvesting at these times and places (Garcia-Moliner 1985, Colin et al. 1987, Sadovy et al. 1994). Over-harvesting of the most vulnerable species can lead to local extinction of smaller herbivores. In addition species that aggregate during spawning, such as groupers and snappers, are vulnerable to over-harvesting at these times and places (Garcia-Moliner 1985, Colin et al. 1987, Sadovy et al. 1994). Over-harvesting of the most vulnerable species can lead to local extinction of smaller herbivores. In addition species that aggregate during spawning, such as groupers and snappers, are vulnerable to over-harvesting at these times and places (Garcia-Moliner 1985, Colin et al. 1987, Sadovy et al. 1994). Over-harvesting of the most vulnerable species can lead to local extinction of smaller herbivores. In addition species that aggregate during spawning, such as groupers and snappers, are vulnerable to over-harvesting at these times and places (Garcia-Moliner 1985, Colin et al. 1987, Sadovy et al. 1994). Over-harvesting of the most vulnerable species can lead to local extinction of
spawning stocks. This is because prices tend to rise, as more desirable species tend to become rare, making it profitable to continue to fish them.

Problems in Caribbean fisheries range from coastal zone degradation, over exploitation of resources, resource allocation disagreements and conflicts, as well as habitat destruction. In recent years these problems have surfaced in various areas, varying enormously in scale. In different marine resource areas one or more problems may be more dominant; in others the degree of crisis may be small or non-existent. Whether a large problem or an individual crisis, they have a spatial dimension. Marine fisheries may be considered as the world’s most spatially extensive economic activity, and many problems associated with marine fisheries and resource extraction have their root in uneven spatial distribution of resources. Better spatial management practices are needed to explore, alleviate and control some of these problems. There exists a series of applications to which Geographical Information Systems (GIS) could be put in fisheries management throughout its entire remit (Caddy and Garcia 1986). Overfishing could be a result of spatial uncertainty in the location of new productive fishing grounds for particular species. Unequal spatial access to a particular fishing stock resource due to its varying spatial distribution needs careful resource allocation management.

Before GIS were available, studying the spatial patterns and processes in the marine environment was time consuming and difficult, but the new technology provides better opportunities to bring a spatial component to fisheries management. GIS are a maturing technology for exploring and solving spatial problems. Since computerized GIS emerged in the 1970s, they have moved from high cost, difficult to use programmes needing highly technical input and significant patience in developing datasets and seeing results, to more affordable, simpler to use packages, and in many applications datasets can be bought from third party sources (Longley et al. 2001).

GIS are a powerful set of tools for collecting, storing, retrieving at will, transforming, and displaying spatial data from the real world for a particular set of purposes (Burrough 1986). Their application was derived from two major sources in the 1970s and 1980s, the cartographic tradition displaying thematic maps as points, lines or polygons (vector), and the thematic tradition where surfaces were divided into equal-sized cells or pixels and values attributed to them (raster). While early systems were two-dimensional, representing the earth on a flat piece of paper of computer screen, later models were 2.5 D, where one attribute is elevation (Triangular Irregular Networks or TINs and Digital Elevation Models, DEMs, are two examples). GIS can be appropriate to research, management, and planning of almost any application, and the fisheries industry can make some use of these (Bremman 2002). However, the sophistication needed for data and the technologies to analyse them are often beyond the reach of Small Island Developing States (SIDS) in the Caribbean. Despite this, there are some simple GIS techniques that can be applied to fisheries management and this paper explores recent experiences in the British Virgin Islands (BVI).

GIS functionality is far more than a computerized map. Data layers can hold not only locational information (their coordinates) but also attribute information that can define both qualitative and quantitative properties of an
individual feature, including time (Longley et al. 2001). This attribute information can be queried in various ways:

i) What is where – pointing to a particular location on a map and asking what attribute value can be found.

ii) Where is what – querying the attribute table and showing all locations where those values are found. This can be a sophisticated query that can synthesize several attributes and conditions to provide a solution.

iii) What is within a distance of... e.g. show all the landing sites within 3 miles of the main fish market.

More sophisticated analysis can be achieved by taking more than one dataset; we can locate where suitable location sites are found, use buffering (mapping an area to a certain distance from a feature) or overlay (combining layers and evaluating attributes based on their shared location) or evaluate the influence of a site by its distance from another type of feature (e.g. a location of suitable anchorages could be derived from by overlaying a depth layer with a substrate layer, and buffering away from precious coral reefs to a distance of 50 m). First, we can model data to produce imaginary “what if” scenarios, e.g. what area of coastline would be inundated by a 2 m sea level rise (Burrough 1986).

With such tools, GIS not only maps the environment, which is a powerful aid for a user to interpret a situation, it also allows forms of analysis of spatial problems that no other technology can handle. Also, it provides a useful repository within which data from a diverse range of sources can be synthesized and analyzed. A whole science on data models, data input, visualization theory, query, analysis and modelling has arisen from this complex technology (Longley et al. 2001), but the simpler user interfaces, the market availability of large, up to date and accurate datasets, and better training and manuals have made GIS accessible to non-GIS specialists such as fisheries managers. It has also opened applications in marketing, defence, natural resource management, agriculture, meteorology, land ownership, utilities, facilities management, social and economic studies, and geology. Despite there being great potential for use in marine studies, much of its application remains land based.

**WHY THE SLOW TAKE UP?**

There are several technical and non-technical reasons why fisheries management has not widely adopted what could be a vital tool. Technically, the early data models (vector and raster) suited land-based applications which relied on only knowing surface geography, but fisheries management needs to take account of the oceans’ true 3-D nature. Even TN and DEM models purporting to have elevation do not satisfy the needs of fish management, as they can only represent one piece of information at a particular “x,y” location. A true 3-D model would be able to store “x,y” and “z” coordinates spatially, and store attributed information for every unique x,y,z position. Fish shoals, water temperatures, current flows, plankton beds could then be accurately located within the water body.

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A second technological problem is that traditional data models do not cope with the fuzzy nature of marine information. The vector model relies on precision location of features, as it came from the cartographic tradition where building edges, roads, and fences needed to be accurately placed. The raster model’s boundaries depend more upon satellite sensor specifications rather than any ground feature. Natural phenomena are much more likely to have imprecise boundaries, merging in a gradual transition from one form to another (e.g., a seagrass patch may reduce in density at its edges before reaching an empty sand bed). GIS modelling also cannot characterize the inter-variability of a patch of seagrass easily. While all GIS data are subject to inaccuracies from age of data, areal cover, source map scale, density of observation and relevance, von Meyer et al. (2000) argued that marine data are particularly suspect because of their inherent fuzziness.

A third problem is that sea-based phenomena are rapidly altering and fluid, and their position, characteristics, and boundaries change swiftly. The combination of fluid situations and their 3-D nature means that in order for them to be successfully, massive datasets need to be gathered and updated frequently. No fishery department has the resources (money, time, personnel, or field stations) available to do this efficiently, and even with large storage machines, it would be difficult to archive, let alone process, such huge datasets. In some ways fortunately, this kind of data are not available in the sea, and only sparse and selective sampling of currents, temperatures and fish stocks are possible (Fedra and Feoli 1998). Meaden (1999) has suggested a new hierarchical system of cuboid units (Meaden calls them voxels) which can change in resolution depending on the level of detail could help address these issues, but this remains conceptual.

A non-technical reason why GIS in fisheries has not been widely applied is a lack of specialist GIS people or gatekeepers of funding sources or innovation that can stimulate a fisheries GIS community. Some work in the United Nations Food and Agriculture Organisation, FAO, (1996) and the United Nations Education, Science, and Culture Organisation, UNESCO, (1999) tried to stimulate the field from international cooperation, but “the essential critical mass of young scholars in both the marine and coastal realm, only was providing the necessary leadership and inspiration to help guide and further develop these closely-related application areas” (Wright and Bartlett 2000).

The use of GIS in fisheries management will gradually evolve, but requires two major areas of development. The first is that the methods of data capture will improve. The second is that the conceptualization of a data model specifically for the oceans will be realised. Some progress on a data model has been achieved (Wright et al. 2001)1. Although still a draft, it attempts to address key issues in setting up a comprehensive conceptual framework; incorporating how components of marine environments interact, what data need routine collection, and how useful information can be extracted. In the interim, technologies available to monitor from sea surface to substrate (see any issue of the monthly “Sea Technology”) are just not available either to small nations or the fisheries sector; only defence, oil and mineral exploration can justify the expense. Instead, fisheries management in SIDS must make

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USE OF GIS IN BVI FISHERIES MANAGEMENT

The British Virgin Islands are an archipelago of some sixty islands about 100 km east of Puerto Rico in the north east Caribbean. According to projections from the BVI Development Planning Unit in 2001, the total population of the island is about 21,000\(^1\). Despite having a tiny land area (151 km\(^2\)), it benefits from its position in having an extensive marine Economic Exclusive Zone or EEZ (81,000 km\(^2\)). The seabed encompasses diverse oceanographic features including coral reefs, rocks, banks, seamounts and deep slopes. These features support a variety of fishes and invertebrates, and potentially a very lucrative fishing industry.

Although fishing was the traditional occupation of British Virgin Islanders, commercial fishing presently constitutes a relatively small percentage of Gross Domestic Product (GDP). Annual landings and market values from 1981 - 1997 showed a drop in the contribution of fisheries to BVI’s GDP from 3.3% to 1.3% over that time period (FAO 1998). This downward trend continues with fisheries contributing 1.33% and 1.29% for 2001 and 2002, respectively. These low percentages from such an intrinsically potentially valuable industry are in part due to the market value of the species targeted by the artisanal fishery, as well as a decline in the number of fish caught by traditional fishing methods.

The commercial fishing fleet of the BVI includes approximately 374 fishing vessels and about 176 vessels (Pomeroy 1999). A 2002 census revealed only 77 full time fishers in the BVI. According to a marketing report by the BVI Conservation and Fisheries Department (CFD), traditional fishing gears, which include fish traps and seine nets, account for 80% of annual commercial catch\(^1\). Fish traps are used to catch “potfish” which include shallow water reef fishes such as haemulids (grunts), sparids (porgies), scardids (parrotfish), pomacentrids (angelfish), balistids (triggerfish), lutjanids (snapper), and serranids (groupers). Seine nets target coastal pelagics including small scombrids (mackerel) and carangids (jacks), and scytalidids (ballyhoo and halfbeaks).

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Larger pelagic species (dolphin, wahoo, kingfish and tuna) remain relatively unexploited by commercial fishers. Results of the marketing survey conducted by CFD in 1997 concluded that the peak in fish demand in the BVI was during the tourist season and that large pelagic fish accounted for 61% of the tourist industry demand. In addition, these fish had a market value of from US$1.00 to $2.00 per pound (lb) higher than shallow water reef fish caught by the artisanal fishery (CFD 1997). Significant quantities of larger pelagic species are unavailable to the local market and must be imported and the BVI fishing complex has also imported red hind from St. Vincent and the Grenadines during 2002.

A socio-economic study in 1999 found that the BVI reef-fish fishery is experiencing over-exploitation due to artisanal fishing practices. An estimated 8250 traps were being used in 1999, on and around shallow reef areas on the shelf surrounding the islands (Pomeroy 1999).

The majority of fishers in the BVI believe that fisheries resources are in worse condition 1999 than five years before. Reasons given by fishers include increased tourism, coastal development, illegal fishing, and increased numbers of fishers and traps in the water (Pomeroy 1999). However over-fishing may be a result of spatial uncertainty in the location of new productive fishing grounds for a particular species. Many fishers are interested in diversifying their fishing methods to enable them to fish on the deeper banks and drop-offs, away from over-exploited near shore waters. Therefore potential benefits of the use of GIS are identification of new fishing grounds based on habitat depths, and other physical parameters. Linking geo-location and other techniques/scientific evidence on mechanics and quantification of changes in fish stock structure may provide more compelling arguments to fishers to support (periodic) closed areas.

In the BVI GIS is an integral tool of government, which is moving from separate departmental installations to an integrated National GIS (Mills et al. 2003). Within a shared database, catalogued centrally, a number of applications are being developed, including a Cadastral Information System, an Agricultural Information System, a Planning Information System and Environmental Information System (EIS), within which fisheries management sits. The NGIS has grown from a Coastal Resource Information System (CRIS) supported by the Organisation of Eastern Caribbean States (OECS) Natural Resource Management Unit (NRMU) that piloted the metadatabase, database and user interface components (Mills et al., 2000). Until 2001, few fisheries applications made any direct use of GIS (Pomeroy’s 1999 report being the exception), but these are now developing. Table 1 explains the list of fisheries applications that utilize or have potential to utilize GIS in BVI, grouped by theme.

3 Braithwaite, B. 2003. Personal commun. BVI Fishing Complex, P.O. Box 699 Baugher's Bay, Tortola, BVI.
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*Note: Table format is used for clarity and organization.*
Aerial photography and Satellite imagery are used in many parts of the world to demarcate areas of similar habitat from which field survey can verify the results (e.g. Munby et al. 1999, Sheppard et al. 1995). These resource maps can be used to quantify the area of strategic habitat types. BVI was the first in the region to obtain a comprehensive resource inventory of its coastal waters (Blair Myers et al. 1992). From 1991 aerial photography, polygons of similar habitat were derived, and a series of field surveys were used in a cluster analysis to derive 33 classes, grouped into reef building corals, mangrove, seagrass, miscellaneous communities (soft corals, algae), substrates and other features (Sheppard et al. 1995). The resulting maps at 1:15,000 scale gave information out to depths of up to 15 m in some areas (Figure 1). This data layer still forms the basis for many fish surveys, identification of nurseries, and scientific studies linking habitat to fish resource (e.g. Munro and Watson 1999) as well as being part of strategic planning in 2000 for proposed marine national parks. A comprehensive assessment of the fisheries at Hans Creek, an inlet on Beef Island, used GIS to create a more detailed map of the habitats in the creek, and has been used in a series of studies looking at this vital nursery (Munro and Watson 1999, Watson et al. 2000).

Other waterborne parameters can also be monitored and mapped (e.g. water temperature, pollutants, salinity) by repeat measurements at fixed locations. BVI has found that by detaching these databases from GIS proves useful in getting better acceptance and uptake by fisheries specialists, so have developed user-friendly Microsoft (MS) Access databases which can be connected to the GIS only when a mapping component is necessary using Open Database Connectivity (ODBC) functionality available in any MS Windows platform. BVI are working on using these in a comprehensive island system management GIS, linking watershed characteristics and activity to embayment resource health (Lettsone and Mills 2003). Scientific studies in biomass, biodiversity studies, linking fish abundance to environmental parameters, have made use of GIS through regression and other statistical techniques (e.g. Erichthe and Oxenford 2001) in other parts of the Caribbean.

Fish catch data have been routinely gathered from the Government Fishing Company in Road Town since November 2001, and fishers have been asked to broadly indicate where they are fishing, using a 4 km$^2$ map grid of shelf waters. A detailed database has been created of catch total, and divided into total weight by species and sample length and weight. As sample weight and individual fish of each sample are linked to the grid square, maps can be derived to characterize various aspects of the fishery.

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4 British Virgin Islands National Parks Trust. [2000]. A Synthesis of Parks and Protected Areas System Plan for the British Virgin Islands, Revised; 189 pages; unpubl. BVI National Parks Trust. P.O Box 860 Road Town, Tortola, BVI


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From the samples measured, the average length and weight of individual species can be mapped (Figure 2) or the total weight caught of a particular species in a zone (Figure 3), and an indication of fishing pressure can be derived from a map of total number of catches (Figure 4), which shows in BVI that inshore fishing predominates. Where the real power of GIS comes to the fore, though, is by comparing fish catch data, such as number of species caught in a zone that indicates a crude biodiversity measure, with some other factor such as resource. By intersecting fish zones with the coastal resource inventory, aerial statistics of shallow resources types could be compared with number of species found, to see whether particular assemblages of habitat give greater biodiversity. Once the database has been in use for a longer period, other analyses should be easily obtainable in terms of Catch Per Unit Effort (CPUE), and trends could be mapped for any period specified (e.g. years or seasons). After a few years of data collection, significant trends in fishing effort and habitat related species composition of catch may enable predictions for the exploitation of new areas in BVI's expansive fishing shelf.

Figure 1. Simplified Coastal Resource Inventory (1992) of Beef Island Airport area.
Figure 2. Average weight and length of red hind (Epinephelus guttatus) for each fishing zone for period November 2001- November 2003.

Figure 3. Total catch weight (kg) of queen triggerfish (Balistis vetula) for each fishing zone for period November 2001- November 2003.
The socio-economic study conducted by Pomeroy (1999) into the fisheries of BVI included the identification of primary, secondary and tertiary fishing zones based on fishers landing sites in BVI. This study featured a base map, prepared by the BVI Survey Department and adapted by CFD, which included major islands in the BVI and USVI, territorial borders, major fishing banks, depths and depth contours. Four km² grid squares were superimposed on the map to facilitate easy identification of fishing grounds by fishers. This formed the basis of the current fish landing monitoring mapping described above.

The use of the grid square system has also increased the ability of surveillance teams to pinpoint where infringements are taking place. Data layers showing the agreed international borders can help identify when a foreign fisherman may have strayed into local waters and be mapped against jurisdiction data.

Proposed and actual locations of Fish Aggregation Devices (FADs) have been mapped with the prospect for both FAD management and monitoring, to investigate whether they increase both fishing activity and better catch effort around them. Also, by locating fish landing sites and linking the proposed fish licensing database containing details of boats, gear, fishermen, and storage methods, it is hoped work of Pomeroy (1999) can be taken forward from a single study to a routine part of monitoring and evaluation of the fishery industry in BVI, linked to specific locations.

The integration of several data layers; coastal resource, existing jurisdiction (national parks), moorings, and local fish knowledge were used to propose industry in BVI, linked to specific locations.
where fishing protection and priority areas could be established. The resultant maps helped decision makers identify potential conflicts of use could occur and assess the overall impact before proposing a resolution (Figure 5).

Figure 5. Marine resource use conflicts, such as between fisheries, tourism and environmental protection can be analysed and resolved by overlaying different interests in GIS.

Despite this progress in using GIS in BVI fisheries management, serious gaps in knowledge still occur. Only a rudimentary bathymetry map is available, although the drops and banks are reasonably sited. Only local knowledge of currents is available, and there has been no systematic study of current dynamics in the myriad of channels surrounding the islands. Water temperature and salinity are sporadically measured. To achieve these vital pieces of information will take a partnership between several government departments who can use the data, and international efforts to coordinate large data gathering exercises to produce cost efficiencies individual states cannot hope for. Additionally, the recording of fish catch data from the BVI Fishing Complex only captures around 30%\(^6\) and improved reporting would help give a better picture of fishing pressure in BVI waters.

\(^{6}\)Brathwaite, B. 2003. Personal communication BVI Fishing Complex, P.O. Box 699 Baughers Bay, Tortola, BVI.
BVI marine environment stakeholders already collaborate to share data, work together on field surveys, share computer and field resources and prioritize information needs through the existence of the National GIS (Mills et al. 2003). This is helping to reduce data redundancy and duplication and provide a multi-purpose framework for a host of applications. Additionally, there is also some collaboration with regional and international institutions to avoid reinventing the wheel both in conceptualizing what is best for obtaining information, and in the practicalities of achieving it. New data sources from international websites or from cheaper and better access to satellite data would also improve insular resource management in countries like BVI. In particular, American agencies such as the National Oceanic and Atmospheric Administration (NOAA) are routinely publishing meteorological and sea surface state information. Although at too coarse a resolution for BVI at present, with a twofold increase in detail, this could provide an excellent overview of the EEZ.

GIS has been seen as a wonderful resource for decision makers in government in particular, as information can come from diverse sources to a single interrogative environment. However, local people are suspicious of giving information to decision makers, as it disempowers their knowledge base (Pickles 1998). Fishermen, in particular, are reluctant to accurately locate where their catches were taken, as they are suspicious that the government will regulate against them or give the information away to competitors. While information is a vital tool in improving management, even co-management of fisheries, its handling and distribution should be carefully controlled to avoid abuse which could disenfranchise and disengage the fishermen forever. More studies on how the use of GIS could be more beneficial to individual fisher- folk would be advantageous.

CONCLUSIONS

The use of GIS in fisheries management in the BVI is fledgling though expanding rapidly. It has been restricted by the same international trends mentioned at the beginning of the paper, but has also suffered from growing from a small institutional base with a limited budget. Programmes are trying to streamline data flows into GIS, instead of setting up discrete databases, the same information sources that serve other statistical and search functions can be simply adapted (with the use of x,y location coordinates) to serve a mapping function. Once a single well designed database exists, data can be manipulated, summarized, aggregated and recalculated in many different ways, and the results shown as points (landing sites, surveillance reports), lines (transects), or polygons (fish catch in zones). Making best use of what exists and publicizing it thoughtfully to the decision makers will help in getting support to fund filling those vital gaps in our marine knowledge base (especially better catch reports, bathymetry, deep substrate and current). Iterative programmes that gradually enhance capacity and involve entire fishing communities is a must, so as to ensure the development of appropriate applications. And perhaps with international effort for utilizing new technologies and conceptualizing how GIS should most efficiently be used in fisheries management, we can start to make the dream of a seamless, timely 3-D GIS

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