

# WebGIS for Reef Fishes Biodiversity at Nha Trang and Cam Ranh Bays in Khanh Hoa Province, Vietnam

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**Abstract**—Nha Trang and Cam Ranh Bays have a range particular importance for marine biodiversity, where concentrate coastal fishing grounds. However, it is strongly affected from human activities such as overexploitation, destructive fishing, contamination, leading to impairment of natural resources.

A WebGIS is designed with tools and features that are common on Web pages, so it is easy to understand for users familiar with the Internet. Currently, WebGIS are rapidly applied in biodiversity assessment and conservation.

For biodiversity research, reef fish were collected at Nha Trang and Cam Ranh Bays from 2013 to 2014. More than 30 species were identified by morphologic and genetic characters. Our research aim to develop an interactive WebGIS and database of reef fishes biodiversity.

We use ArcGIS Desktop and ArcGIS Server, commercially available software, which was extended using a Visual Basic to customize our application. Map and WebGIS were set up for the biodiversity data (species composition, distribution, morphologic and genetic characters of reef fish). The database can provide biodiversity information to create the natural resources network, which can be shared effectively between stakeholders for resource management and conservation.

**Keywords**—WebGIS, biodiversity, reef fish, Vietnam.

## I. INTRODUCTION

KHANH Hoa Province is located in the south central region of Vietnam, with more than 300 km of coastline running from 11<sup>o</sup>40 to 12<sup>o</sup>50 Northern latitudes. This region has ecosystems typical of tropical waters, biological diversity and productivity. However, the pressure of rapid population growth, economic and social development, the exploitation and irrational use of environmental resources really threat to the ecology of this area [1]. The previous studies of reef fish biodiversity in Nha Trang Bays focused on investigating the number of species, but mainly based on morphological characteristics [2]. These results were in printed version, thus the sharing, updating, and querying of data is difficult. In recent years, geographic Information Systems (GIS) are widely applied in risk assessment, spatial

distribution, dynamic monitor as well as tendency forecast of crop diseases and pests[3]. A GIS is a computer-based system for managing, storing, querying, analyzing, modelling and displaying map database information. When GIS data and functionality are available on the Internet, the system is referred to as WebGIS [4]. Among web-based geographic information systems, for example Google Maps, Yahoo Maps, GlobeXplore[5] have provided a new generation of interfaces. A common procedure for publishing geo-referenced data on a WebGIS site includes the following steps. First, generate the data to be published; then, upload the data into a map server such as MapServer[6], GeoServer[7], ArcMap Server, ncWMS[8], etc; finally, with a group of programmers and web designers, build the web interface to display the data for users.

In this paper we used ArcGIS® Desktop and ArcGIS® Server-commercially available software, developed by ESRI® in Microsoft® .NET Framework, to custom design a WebGIS application. The biodiversity information of reef fish species are converted to a GIS dataset (ESRI shape file format) and presented as map layers. Users can turn on or off each layer, navigate around the area using pan and zoom, query each layer spatially or by attributes stored in its database, obtain metadata even create geotechnical graphs and plots. The aim is to provide the public and share for the community with a user interface that is intuitive and familiar.

## II. MATERIALS AND METHODS

### 2.1. WebGIS architecture

WebGIS extends a basic Web application by giving it GIS capabilities. This means the basic architecture of WebGIS is similar to Web applications but with the addition of GIS components. A diagram 3-tier of the WebGIS framework (presentation tier, business logic tier and data tier) is shown on Fig.1[9]. The client sends a request to Web server over the Internet via HTTP (Fig.1c). The Web server forwards GIS-related requests to GIS server (Fig.1b). Then, the GIS server retrieves the needed data from the GIS database and processes the request, which can be to generate a map, conduct a query, or perform an analysis (Fig.1a). The data, map or other result is sent by the Web server to client in a response via HTTP (Fig.1b). The client then displays the result to the user, which completes the request and response cycle (Fig.1c). This architecture focused the core part of system on the server can unify the client and simplify the development, maintenance and use of the system. Just installing a Browser such as

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Internet Explorer, Fire Fox and Chrome on the client. The database in the platform can be visited on the server [10].

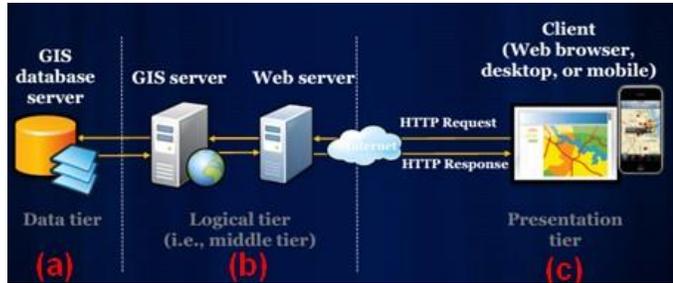


Fig.1 System framework diagram (Fu, 2011)

Components of WebGIS: Database (a); Web-GIS Server/Web Server (b); Client (c).

2.2. Spatial databases design

In this study, the spatial data is vector graphics format, includes images, data types and genetic information. Using ArcGIS Desktop software (ESRI Inc., Redlands, CA) and administrative map of Khanh Hoa Province[11] to digitized information (administrative districts, rivers, islands etc) of the Khanh Hoa Province. The spatial data respectively stored as point, line and polygon (Table i). Digitized map is presented in Fig. 2.

TABLE I  
INFORMATION OF THE SPATIAL DATA

Data Layer	Format	Description
Administrative division	Polygon	Administrative districts boundary of Khanh Hoa
River	Line	Main rivers of Khanh Hoa
Sampling location	Point	Location of Fish-sampling
Island	Polygon	Islands of Khanh Hoa



Fig.2 Digitized map of Khanh Hoa province

Colors correspond to different districts and islands, lines symbolize the main rivers and circle with grid inside represent the sampling locations.

2.3. Attribute database design

Base on the foundation map (Figure 2), additional information on biodiversity (sampling locations, species composition, distribution, morphological characteristics and genetic data (16S mtDNA)) were added in the attribute table

by ArcCatalog - a tool of ArcGIS Desktop (Fig.3). As can be seen, the number of columns and rows corresponds to the number of attributes and species, respectively.

Fig.3 Attribute database of reef fish at sampling locations

2.4. Public to WebGIS

ArcGIS Server and ArcIMS Web Manager allow creating and editing user web mapping applications. WebGIS is initialized with access address is <http://fpgapc/iicbee/default.aspx> by using public tool in ArcMap.

III. RESULTS AND DISCUSSIONS

3.1. Biodiversity map for Reef fish at Nha Trang and Cam Ranh Bays

Combination data from foundation map (Fig.2) with attribute data (Fig.3) was displayed in Figure 4. In particular, information of fish species, DNA sequences and locations are shown on Fig. 4a. Morphological characters are presented on Fig 4b.

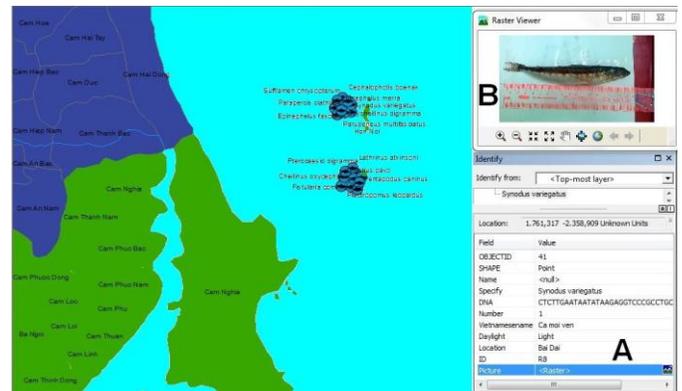


Fig.4 Details of biodiversity map

3.2. WebGIS application

WebGIS application can be connected from clients to ArcGIS Server by Web Browsers. WebGIS interface is shown on Fig. 5. Left column shows the layers of Web map which can be turned on or off to show the details information such as list of rivers, fish species, and islands. While, the right column displays details information as showed in Fig.2 and Fig.4c.

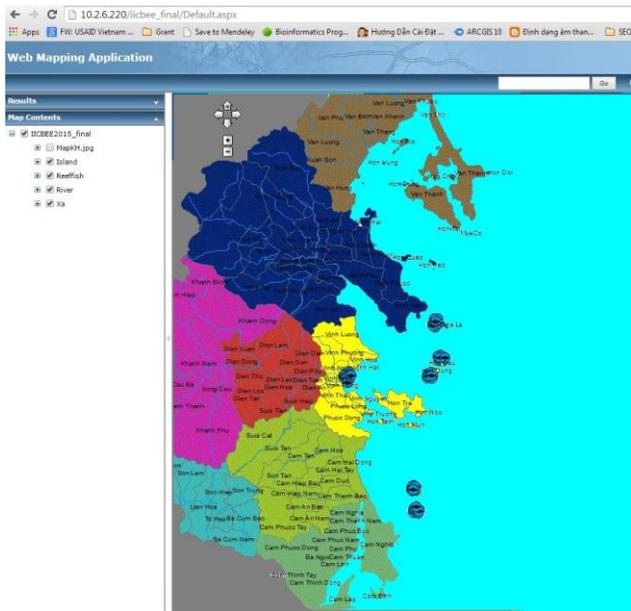


Fig.5 Access WebGIS from a client

Furthermore, WebGIS map functions also have features such as zooming layers; displaying genetic information (DNA sequences, morphological characters, locations, name and image of fish species (Fig. 6a)); listing details of layers (Fig. 6b); finding information about species based on the query function attribute data (Fig. 6c).

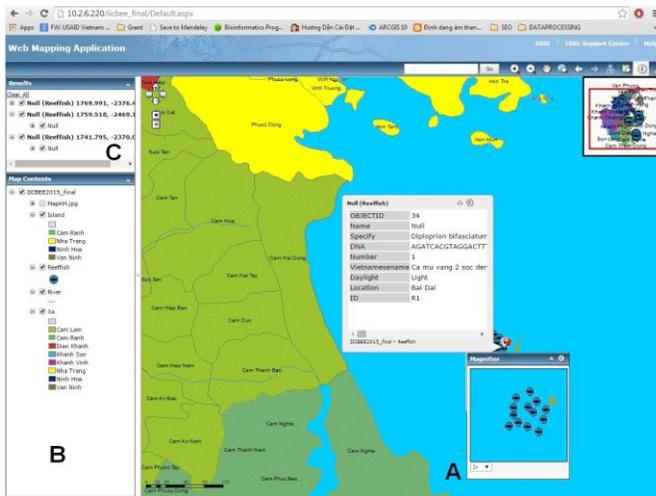


Fig.6 Features of WebGIS

Details of information species (a); details of layers (b); results of species query (c)

### 3.2. Discussions

In the current studies, WebGIS was built based on geographic and biodiversity data for Nha Trang and Cam Ranh Bays using ArcGIS, Visual Basic and ASP. WebGIS application has the potential to share data, provide easy access for users with limited GIS knowledge. The system allows users to query the data in the database; among the sub-layers, users can query the survey data of each fish species, view the image, and find genetic data of each species. Additionally users can apply supported GIS tools to clearly realize the spatial distribution of each species.

WebGIS technology has been applied in environmental management[12], telecommunications infrastructure[13], land protection[14], biodiversity assessment[15] and tourism[16].

Biodiversity Geographic Information System was applied to creating a network of natural resources and ecological data in Taiwan. This application can be shared between the stakeholder, and devote to preserving biodiversity in Taiwan. HABEAS WebGIS provides information on biodiversity and ecosystem services to stakeholders in the Mediterranean Basin (covering Portugal and Bosnia, and Herzegovina), allowing them to explore their natural capital and to create a conservation priority[17]. URBANGENE PPGIS Web-platform create opportunities to involve citizens in a conservation process through the development of a participatory platform to support biodiversity inventory in the Geneva cross-border area[15]. WebGIS is also create for freshwater fish in Mekong Delta, Vietnam (Dang & Doan, 2014), that help users survey and query the fish biodiversity data.

Current WebGIS provide biodiversity data for common reef fish species in Nha Trang and Cam Ranh Bays, Khanh Hoa province, Vietnam. Data will continue to be updated, that will be shared between stakeholders, and applied for resource and biodiversity conservation. Therefore, further research should focus on the following: continue sampling economic and ecology important fish species; improve WebGIS application to meet user request such as statistical data of fish species; the blog publishes the related news and articles about biodiversity.

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