INTRODUCTION TO MARINE EXPLORER (MARINE-GIS)
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BACKGROUND

The original idea of *Marine Explorer* (menu-driven Marine GIS software, not requiring user programming) was born in 1985-1991 when Dr Nishida (co-developer) worked in the Fisheries Department, FAO of the United Nations. A similar idea occurred to Dr Itoh (co-developer) in the 1990s after his 1993 establishment of the Environmental Simulation Laboratory Incorporated. Dr Nishida started to work at the National Research Institute of Far Seas Fisheries (Japan) in 1992 after his assignment in the FAO. He and Dr Itoh first met in 1995 during the marine GIS symposium at the Tokyo University.

After they discussed their common idea to develop *Marine Explorer* they applied to the Agriculture, Forestry and Fisheries Research Council, Ministry of Agriculture, Forestry and Fisheries, Government of Japan, for special research funding for a Government–Industry cooperative project. Their application was accepted and the initial stage of *Marine Explorer* was developed during the two-year project period (1998-1999). The participating agencies were Environmental Simulation Laboratory Inc. from the industry side, and, the National Research Institute of Far Seas Fisheries, the National Research Institute of Fisheries Science and Hokkaido University from the Government side. On completion of the project, *Marine Explorer* was commercialized by the Environmental Simulation Laboratory Inc. and progressively developed to meet users' high demands (note: Commercialization was a condition of the Government–Industry cooperative project).

At the present, 14 years after the development of Marine Explorer began, the 5th version has been released. There are now (as of May, 2008) more than 200 users in 12 countries and one International Organizations. World-wide, *Marine Explorer* is still the only menu-driven and user-friendly GIS specialized for spatial analyses of fisheries and aquatic information.

OUTLINE

Marine Explorer marine GIS is menu-driven software specialized for fisheries and aquatic spatial-data analyses without user programming. The fundamental function of *Marine Explorer,* like that of terrestrial GIS, is to conduct spatial data analyses, namely: spatial information database; mapping (visualization and overlay); and spatial numerical analyses (such as contour estimations, geo-statistics and area and distance measurements).

In addition *Marine Explorer* has special functions that can handle unique fisheries and aquatic data, such as: fisheries (catch, effort, CPUE, etc); remote sensing (satellite and acoustics); survey (currents, plankton, physical environments such as temperature, salinity, oxygen, nutrients etc); bottom conditions; and others. Table 1 summarizes the functions available in the recent version of *Marine Explorer* including examples of the applications.

MAIN MENU OF MARINE EXPLORER

TABLE 1 ↔ FUNCTIONS OF *MARINE EXPLORER* TO HANDLE FISHERIES & AQUATIC DATA*

Three major functions	Functions (examples of real application)	Software, engines, program environment
Spatial information database	**General GIS functions** ● *Spatial data entry, update, sort, search, filtering etc.* ● *Quality control* Special functions for fisheries & aquatic data ● *World-wide bathymetry database* ● *Fine-scale local bathymetry database* ● *Sonar & echo-sounder (mass data) processing* ● *Satellite data processing (e.g. SST, Ocean color, sea surface height etc)*	● MS/Excel ● MS/Access, ● Other database ● Satellite data processing programs (20 types) ● GeoTiff (acoustic data processing)
Visualizations and mapping (2D and 3D)	**General GIS functions** ● *Visualization by symbols (50 types)* ● *Overlay (128 layers)* ● *Polygon (for non grid type data)* ● *Composite satellite images* **Special functions for fisheries & aquatic data** ● *Contours (horizontal and vertical)* ● *Buffering (EEZ, MPA, Moratorium area)* ● *Presentation of bathymetry* ● *Trajectory of conventional, archival & pop-up tags* ● *Tracking of the movement of vessels (GPS)* ● *Pinger tracking of animal movements* ● *Management (detection of IUU vessels, effort control, and monitoring fisheries by VMS)* ● *Satellite (SST, Chlorophyll a, sea surface heights and currents)* ● *Current data (ADCP)* ● *Eco sounder (fish distributions from echograms)* ● *Sonar (composition of mosaic images to depict bathymetry)*	● MS:/Dot NET Framework ● Suffer ● GeoTiff* (acoustic data)
Spatial numerical analyses	**General GIS functions** ● *Computations of area and distances* **Special functions for fisheries & aquatic data** ● *Gridding (catch, CPUE, SST etc)* ● *Contour (density) estimations by kriging techniques (SST data from CTD)* ● *Computation of average and anomaly distribution* ● *Habitat Suitability Index (HSI)* ● *Pin-point forecasting of fishing & oceanographic conditions by match-up analyses using grid data including satellite information* ● *Geostatistics (spatial GLM)* ● *State-space model (Bayesian processing)* ● *Spatial stock assessment (Production models, VPA and integrated models)* ● *Analyses of currents and tides*	● Suffer ● Spherical trigonometry for the globe (to compute accurate area and distances)

Note (*)
Fisheries and aquatic information
- *Fisheries data :*
  Catch, fishing effort, CPUE, species composition, bycatch etc.
- *Biological data:*
  Size, weight, gonad index, fecundity
- *Environmental and ecological data*
  Temperature, salinity, oxygen, bathymetry, currents, nutrients, prey, predators

Data sources:
- *Commercial fisheries, surveys (CTD, ADCP, plankton net, echo sounder, sonar etc), tags (conventional, archival and pop-up), artificial reef, FADS, satellite and others.*

PROSPECTS OF MARINE EXPLORER

Next-generation Marine Geographic Information Systems

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Abstract

Marine Explorer (ME) is the GIS software specialized for the fisheries and aquatic information including the satellite and acoustic data. The ME requires no programming to operate as it is driven by menus like MS windows and Excels. The ME has been evolving in past 14 years since its start of the development in 1995. The ME is designed for those who wish to do the spatial analyses quickly and effectively without any programming. Although the ME is the menu-driven GIS software, ME include all types of GIS functions and can perform spatial analyses from simple mappings (e.g. distribution of catch, CPUE, etc), overlaying of multi parameters, contour estimation (e.g. SST) to advanced spatial analyses such as fishing ground forecasting, geostatistical analyses, abundance estimations, etc. At present more than 200 users in 12 countries and one International Organization (as of May, 2008)   are utilizing the ME and contributing in various areas such as Industries, Government Agencies (research, compliances, planning, VMS-satellite monitoring and mangers), Research Institutes (fisheries resources analyses and ecosystem research) and Universities (education and research). This paper shows the evolution of the ME from the first generation (version) to the fourth and also to the next generation of the ME.

Key words

next generation GIS, satellite, acoustics, fisheries, oceanography, Marine Explorer.

1. Introduction

In general terms, Geographic Information Systems (GIS) offer a group of tools which can be utilized to process, present and display a variety of data in an array of useful ways. These ways include distribution or overlay maps, measurement of distances or areas and spatial analysis of positional information. This wealth of capabilities means that end users are advised to customize GIS programs to reap maximum benefits from the software and ensure that GIS work cohesively to achieve the users' objectives.

Marine Explorer is a marine GIS software program specially designed to provide users with data processing and fisheries oceanography data analysis capabilities while doing away with the need for macro programming. In short, this means the necessary functions are built in so that users can enjoy the benefits of high-powered calculations and data displays through an interface offering simplified operation commands. In this way, users can spend more time for their important genuine (original) works instead of spending a lot of time for programming. However, the pace of digitalization and progress of sensor technology has resulted in situations where the demands of data processing have out-paced conventional data handling methods. To improve this situation, Marine Explorer has upgraded its data processing functions to reflect the requirements of new sensors.

2. Evolution of Marine Explorer

Below is a summary that traces the history of version upgrades of Marine Explorer and describes the major characteristics of each advance.

## 2.1 The first generation (Version 1)

Shown in Map 1, this is the most basic GIS whose main function was to plot distribution maps of catch data on oceanographic charts.

Map 1.

Sample distribution map produced by first generation Marine Explorer
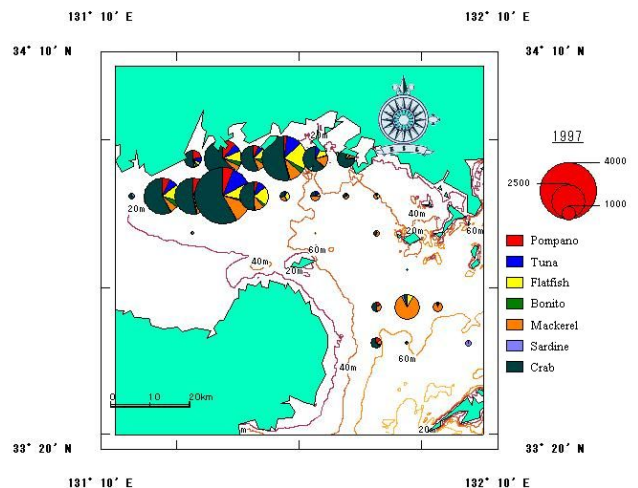
2.2 The second generation (Version 2)

Using this version, data collected by oceanographic data measuring equipment (such as CTD and ADCP sensors) and compiled into databases could be used to create distribution maps or overlay maps (e.g. Map 2) by following a simple set of commands. This upgrade also expanded the areas covered by Marine Explorer to include oceans in addition to coastal areas.
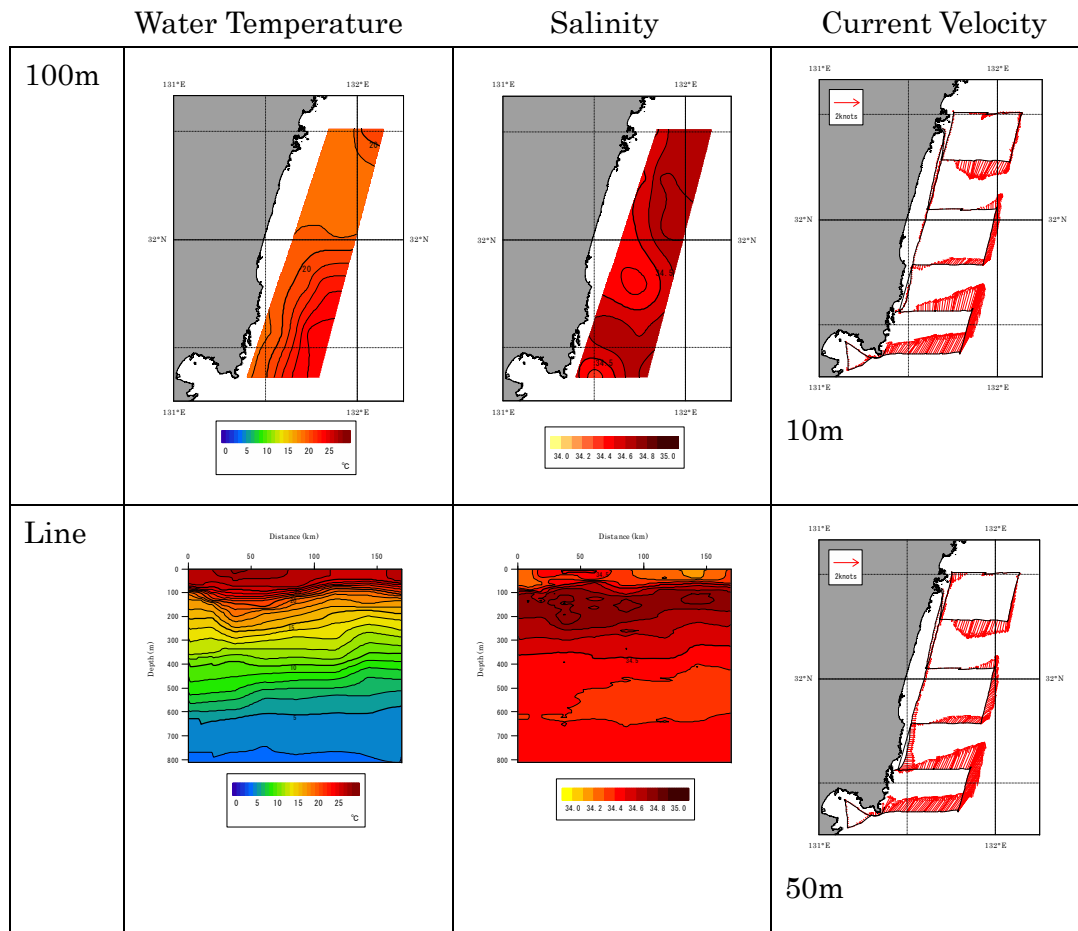
Map 2.   Oceanographic observations, produced with Marine Explorer (Version 2).

The third generation (Version 3)

Software capabilities were further expanded to handle satellite data, such as sea surface temperature and ocean color (Map 3). In this way, oceanographic and catch information came to be freely manipulated using one system.

Sea Surface Temp.

Sea Surface Height

Ocean Color

Ice Concent-ration.
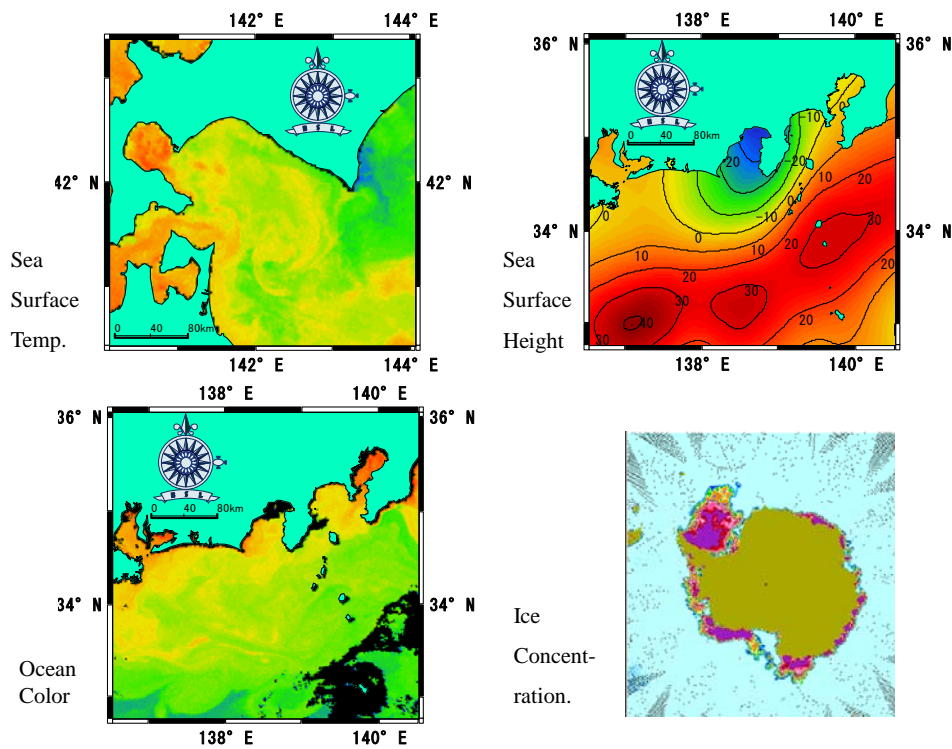
Map 3.   Satellite data for Marine Explorer (Version 3).

The fourth generation (Version 4)

Using version 4, all data for use in fisheries studies and oceanographic sciences could be compiled into a database and displayed. In addition, spatial analysis functions, such as area calculations, grid calculations, average map functions and deviation map functions were enhanced. Moreover, with this upgrade Marine Explorer was able to handle fisheries oceanography data sets simultaneously for all size scales of marine areas, as demonstrated in Map 4.
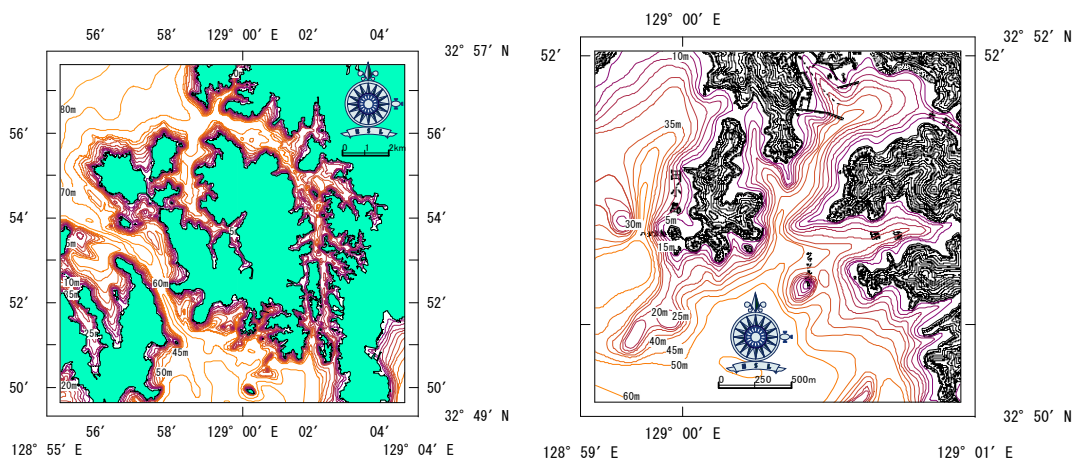
Map 4.   Precise bathymetry map produced with Marine Explorer (Version 4).

3. Next-generation Marine GIS

Until the release of the fourth version of Marine Explorer, the software's primary functions involved the basic processing and analysis of fisheries data. In contrast, recent industry developments have created the desire and the expectation among users for a system capable of more sophisticated applications and calculations such as ecosystem managements.

In response to these needs, Marine Explorer has improved its own processing functions and has been engineered so that its various components can be put together in a variety of ways to create a system meeting specific user requirements. This is especially true for the system shown as in Figure 1, which can accommodate new technologies, such as GPS or satellite data. The system can also handle massive amounts of data, such as that required for side scan sonar images.
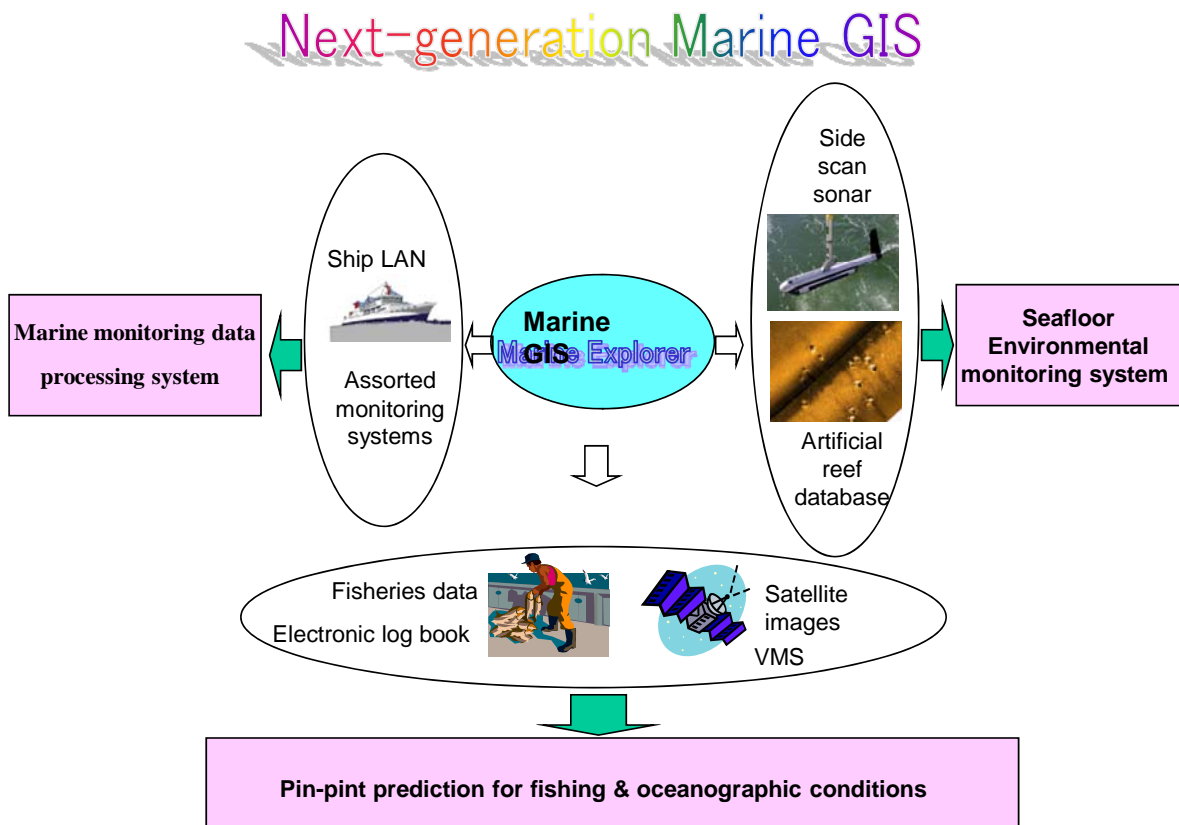

Figure 1. Next-generation Marine Explorer.

3.1 Pin-point fishing ground forecasting system

This system can be used onboard and office. It obtains and uses satellite data in near real time to predict promising fishing grounds for the following day using Marine Explorer satellite processing function. The prediction process is conducted based on the catch data from normal or recently developed electronic logbooks that are analyzed in conjunction with factors such as water temperature and other environmental parameters, to find out fishing grounds that are likely to yield the best catch on a seasonal and geographic basis.

3.2 Sea bottom environment monitoring system

Spatial resolution for side scan sonar images is about 5 cm. As a result, an image covering an area several kilometres in size will exceed one gigabyte. To address this issue, we have developed a special data management system and display techniques to make handling of large images smooth and uploading of such images fast. By overlaying images of the sea bottom and topographic maps of the seafloor, this system makes it possible to pinpoint the location of beds of sea grass as well as artificial reefs. Furthermore, this is the best system for obtaining detailed data and wide-ranging distribution data about the sea floor.

3.3 Oceanographic data processing system

This system links the basic processing functions of Marine Explorer with an onboard LAN system. The system processes observed data into charts and ledger sheets largely automatically, making this data available online on the same day. It contains a quality control check function and makes it possible to process and deliver data in roughly 15 minutes. Until recent years, it would have taken several days to undertake such a task.