Automated Cartography of Fisheries Oceanographic Atlas Using ArcPy Based on Global Time Series Grid Data of Marine Environment

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Abstract: The fisheries oceanographic atlas contributes to the study of fishery location distribution, fish movement law and reveal the periodicity of marine environment change. It provides a more accurate reference for fishery production and sea state trends, and is widely used in marine fishery research. According to the global time series distribution of marine environment and fishery resource, the global time series fisheries oceanographic atlas are drawn. The difficulty of production lies in the repeated drawing steps and massive multi-source data. The automatic production of fisheries oceanographic atlas based on ArcPy effectively improves the drawing efficiency and simplifies the product process, as well as provides a convenient way for batch production of atlas. This paper introduced the cartographic elements of fisheries oceanographic atlas including marine environment data, fishery resource data and foundational base map. According to the data categories and characteristics of marine environment data, analyzed the advantages of grid data in marine data storage, retrieval and reading, and proposes the automatic production technology of fisheries oceanographic atlas based on ArcPy. Summarizing the key of automated production technology by taking the western Pacific skipjack as an example.

1. Introduction

The fisheries oceanographic atlas through describing the spatial distribution of fishery and the state of marine environment are widely used in marine fishery research. With the continuous expansion of China's fishery development space, the scope of fishery activities has gradually expanded from the coastal and offshore to the ocean. As a national strategic industry, pelagic fishing is an important part of building "Maritime Power", implementing the strategy of "going Out" and "Belt and Road Initiative", which is of great significance for guaranteeing the supply of high-quality aquatic products, guaranteeing national food security, promoting bilateral and multilateral fishery cooperation and safeguarding national marine rights and interests. In this context, the production of global time series fisheries oceanographic atlas will help to understand and master the global marine and marine sources, reveal the periodicity, tendency and abnormality of marine environmental change, especially to grasp the global fishery location distribution and the law of fish movement, provide guidance and early warning for the production of offshore fishing as well as promote the development of pelagic fishing.

The global time series fisheries oceanographic atlas refers to the fishery information map based on the global distribution of marine environment and fishery resource data. The cartographic and

expression of the spatial distribution of fishery location and the characteristics of marine environment change in long historical series could provide reference for the management and supervision of marine fishery resource. The cartographic process of fishing oceanographic thematic maps usually use professional software such as GIS to read and process the data, match the data of fishery environment and fishery resource, then symbolize the layer and decorate the surface elements, finally output the map. Using ArcPy provided by ArcGIS 10.0 to produce fisheries oceanographic atlas could solve the repetitive and cumbersome batch cartography, improve work efficiency, save a lot of manpower and material resource, and realize the rapid and accurate production of fisheries oceanographic thematic maps.

At present, scholars in other academic sector of cartography study have used automatic processing of thematic map based on ArcPy, such as Chen ZJ [1] to "map template + variable" driven cartographic scheme research, Yu YS Yu [2] to explore and test the standardization of image map making technology, and Song XP [3] to introduce the thematic variable database based on map making template, taking the thematic map of land ecological assessment of Xinzheng as an example, using ArcPy to realize the atlas production of batch processing.

2. Cartographic elements and data storage characteristics of Fisheries Oceanographic Atlas

2.1. Elements of Fisheries Oceanographic Atlas

The key elements of fisheries oceanographic atlas include: (1) marine environment data, the basic cartographic elements of fisheries oceanographic thematic maps, including Sea Surface Temperature (SST), Sea Surface Height (SSH), and Chlorophyll-a concentration (Chl-a), marine current and other marine environment data; (2) fishery resource data, as well as the necessary fishery data in the fishery forecast, which demonstrates the fishery resource information such as the size of catch, catch population, and catch coordinates position. The fishery resource data mainly derive from actual measurement by marine staff and fisherman [4]; (3) Base map elements, base map elements are used to show the interaction between basic elements and marine environment, including the distribution of basic elements, surrounding environmental information, such as administrative boundary around the fishery, sea area, and latitude and longitude information. The elements of the base map should be as concise as possible, and the hue and color should be mainly light, should not cover the basic information of key elements; (4) Finishing elements, including legend, title, annotation, and text descriptions, are the last added elements of the fisheries oceanographic thematic maps. The finishing elements are used to explain the contents of thematic maps, for instance, the legend of catch size shows abundant and fishing yield of fishery resource clearly.

According to the purpose of cartography, combining global marine environment data with fishery resource data in different time series scales (year, month, week) can express abundant information of fishery and marine environment, such as different species of fish in different map frame, different species of fish in the same map frame or multiple time series of the same species [5].

2.2. Data category of marine environment

The main categories of marine environment data involved in the fisheries oceanographic thematic maps include sea surface temperature, sea surface height, chlorophyll concentration, current and other marine environmental factors. All marine environmental elements are constantly changing in a time-series manner.

SST is one of the most important factors in the marine environment, which directly affects fish population distribution, migration and reproduction. As fish always take the initiative to choose the optimum ambient temperature, we can predict the location and distribution of fishery and the time and space migration path of fishery preliminarily according to the sea surface temperature. In addition, marine environmental phenomena such as oceanic front and vortex can also be analyzed based on the sea surface temperature data [6].

Monitoring of sea surface height and height anomaly can predict the occurrence trend of ocean current and circulation, and the mesoscale ocean dynamic characteristics such as oceanic front and water mass can be analyzed through SSH. Furthermore, SSH should also be considered when the

factors such as water mass, water systems and currents are studied in the fishing condition and fishery forecast [7].

Chlorophyll-a concentration reflects the content of marine phytoplankton and the level of marine primary productivity, as well as affects the quantity of fish resource. Based on the principle of marine food chain, chlorophyll concentration could be used to estimate the abundance of plankton-fed fish resource, so as to detect the movement path of fish and the spatial distribution of fishery.

Ocean currents are common forms of motion in seawater, and the acquisition of ocean current is helpful to understand the law of sea-air movement in large scale and all directions. Horizontal movement of ocean current causes local changes in the marine environment, which affects the movement, migration and distribution of fish. Changes in force or flow of the ocean current will also affect the migration path of fishes and the location distribution of fishery [8].

With the rapid development of satellite remote sensing technology and the gradual increase of the sensor types, monitoring and acquisition of SST, SSH, SSHA, Chl-a and other marine environment data through satellite remote sensing technology has become mature and operational applications.

Remote sensing of marine environment field is carried out by satellite with various types of sensors, then the actual numerical values of sea condition data are retrieved by remote sensing, and the marine environment information features such as sea water isotherm, contour and chlorophyll concentration distribution are obtained by using ArcGIS for geo-processing of the actual numerical value of ocean surface.

The marine environment is monitored by remote sensing with various types of sensors carried on satellites, then the true values of marine environment data are obtained by remote sensing inversion. The marine environment information characteristics, such as sea water isotherm, contour and chlorophyll concentration distribution, which are the important background of fisheries oceanographic atlas, are obtained by geo-processing with ArcGIS.

2.3. Storage characteristics of marine environment data

The ocean is a dynamic, continuous, boundary-blurred space-time carrier, usually manifested as global statics and local dynamic [9]. Global static refers to the certainty and stability variation of global ocean as a whole compared to the land area, and local dynamic refers to the study of the changes occurring in the certain areas, which is conducive to analyze the periodicity, regularity and anomaly of the ocean. Marine environment is regular and long periodic, therefore, long historical series data in the study marine dynamics, explore marine regularity is necessary. Common sources of marine environment data are from remote sensing, ship survey data and buoy data currently [10]. Marine environment data usually presents the differences in storage format, reading means and retrieval method, remote sensing detection of marine environment has become the most important source of marine environmental data, due to its ability of synchronizing, large-scale and real-time access to data. The storage and application of marine environment data require the spatial location associated with data attributes, most of atmospheric model data and marine environment data are stored in grid data format.

Grid data refers to the data format that contains multiple attribute information associated with geographic location. Grid data can store a variety of attribute information, which coincides with the multidimensional nature of ocean data, and can reduce the storage and transmission time of data. Grid data is generally stored in Network Common Data Format (NetCDF) and Hierarchical Data Format (HDF) and NetCDF format has become dominant data application format in atmospheric science, marine science, environmental simulation, geophysics, etc [11-13].

NetCDF data format as a single-valued function with multiple independent variables, including header files and data [11]. The header file is a self-describing file, which describes the inclusive variables, dimensions of the variables, and attributes of the variable. The data is the real data of the variables in the file. In NetCDF file, the structure of variables is determined by dimension, including latitude and longitude of variables, time record, and sea surface temperature, sea surface height, etc., as well as the attribute variables describe auxiliary information such as unit of variable.

In addition to the NetCDF data format, the commonly used grid data storage format is hierarchical file format HDF, which is a hierarchical logical structure with self-descripting, self-organizing,

extensible and shareable. HDF5 consists of two basic objects, group and dataset, and groups contains 0 or more datasets. In the HDF logical structure, the entire file as a "root" group, under which other groups or datasets can be included, and the layers are nested to form a complex data format similar to the queryable index [14-15]. HDF format have many advantages such as rich data types, strong extensibility and cross-platform support, which are widely used in remote sensing field.

3. Method of automatic production technique for fisheries oceanographic atlas

Production of thematic maps is an important function of ArcGIS. Some studies have used the Avenue of database and ArcView to make an atlas of fishery fishing environment [5]. Some studies have used the database and Avenue of ArcView to make atlas of fishing environment. ArcGIS has abandoned ArcView and its secondary development language Avenue since 8.0, developed ArcObject to reconstruct the desktop GIS, and launched a series of software update. After abandoning the VBA of 8.0 version, ArcGIS began to move to Python for secondary development. Before 9.3, it was the Geoprocessing module, and it began to use the ArcPy package since 10.0. With the update of GIS software, cartographic technology and process need to be optimized continuously.

3.1. The modules involved in ArcPy

In the usual application, people use ArcMap, a user desktop component of ArcGIS, to product thematic maps in various fields. However, the production of fisheries oceanographic thematic maps of global time series involves a large number of marine environment and fisheries resource data, which requires constant replacement and adjustment of two basic elements to complete the output of multiple graphs. The cartographic process is simple, but tedious and exhausting.

In order to reduce the workload of mapping, improve the efficiency of cartography and simplify the operation process, the automatic production technology of fisheries oceanographic can be realized by ArcPy. ArcPy introduced by ArcGIS provides a feature-rich dynamic environment for developing python scripts. By calling Python site package ArcPy, you can achieve a variety of processing work, such as geographic data analysis, data conversion, data management, and map automation creation. In general, ArcPy is organized by tools, functions, classes, and modules, accessing classes through ArcPy enables parameterization of geoprocessing tools, accessing functions enables call to all geoprocessing tools. Modules are Python files that typically contain classes and functions, including cartographic module (arcpy.mapping), spatial analysis module (arcpy.sa), and the geostatistical analysis module (arcpy.ga).

In this paper, the cartographic module is used as the core module in the study of automatic production technology of global time series fisheries oceanographic atlas. The arcpy.mapping module is an automated map management and output workflow which provides functions that focus on existing map layers and layout elements, and can be used to solve repetitive and cumbersome task in thematic map with a simple call and the arcpy.mapping module contains classes that encapsulate almost all of ArcMap's map operations. The MapDocument classes involved in this study can obtain .mxd documents under specific paths as well as important document information elements; The StyleItem classes can directly read. style files to complete symbolic of thematic elements, users can also design style symbols according to cartographic requirements, which can be saved in the style library to be called. At present, the direct modification of layer style symbols cannot be realized in ArcPy. mapping module. In this paper, the style modification of the thematic elements is to save the pattern layer, and use arcpy. ApplySymbologyFromLayer_management to modify the style of the whole layer.

3.2. Technical Route of Fisheries Oceanographic Atlas batch processing

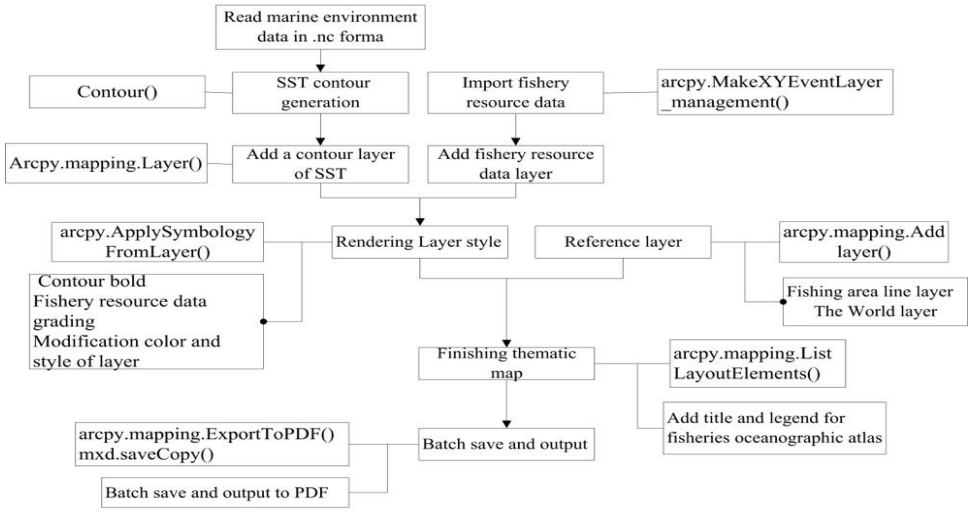

Figure.1. Technical Route of Fisheries Oceanographic Atlas batch processing

3.3. Import of global marine environment grid data

Global time series marine environment grid data is divided into time series. To import grid data, we can use ArcGIS Multidimension toolbox to process NetCDF format data, and realize the creation and conversion of NC files to the raster layer. Besides, we can also use arcpy. MakeNetCDFRasterLayer or other language like IDL and MATLAB which have the advantage of matrix operation to batch import grid data. In the article, the optimal interpolation of the global SST monthly average data is saved as ESRI ASCII GRID format with each time series fragment using IDL. It should be noted that the NetCDF file of marine environment grid data is an integer data storage, which needs to be converted into floating data to obtain the real marine environment information.

3.4. Import of fishery resource data

Fishery resource data is usually derived from the fishing log of fishing vessels, and fishing data are imported by matching the longitude and latitude position, catching category and time series in fishing log.

To import fishery resource data, we can use ArcGIS to add time-matched Excel table directly, select the catching category by arcpy. MakeXYEventLayer and display the data layer in longitude and latitude position, or we can import the original database directly, and then complete the matching of time series as well as display matching data into layer through attribute query. The results of two import method all displayed the target catch data in the single symbolic format, in order to intuitive the display of fishery resource data, the imported data layer should be graded and symbolized.

3.5. Reference map compilation, map finishing and output of fisheries oceanographic atlas

The compilation of the reference map in thematic map should reflect the scope of the thematic map and surrounding environment. The characteristics of marine environment around fishery and the abundance of fishery resource are the essential factors for the performance of fisheries oceanographic atlas. In the mapping of the reference layer of fisheries oceanographic thematic map, it is necessary to highlight the characteristics of marine environment and fishery resource as much as possible, weaken the base layer such as the fishing line layer, the world layer and so on, so as to analyze the relationship between marine environment and fishery distribution and resource clearly and accurately. In order to highlight the feature requirements, such as thickening the seawater isotherm, graded symbols displaying of the fishery resource, the graphical rendering of the color, size and thickness of the

elements is often used to make the information displayed on the thematic maps intuitive and easy to understand.

Thematic map finishing elements include title, border, legend, north arrow, scale, other text and data source information. In this article, the marine environment data and fishery resource data layers are added on the basis of the reference layer, and the mapping module of ArcGIS is accessed through ArcPy to add the title and legend to achieve the automatic finishing of the thematic map.

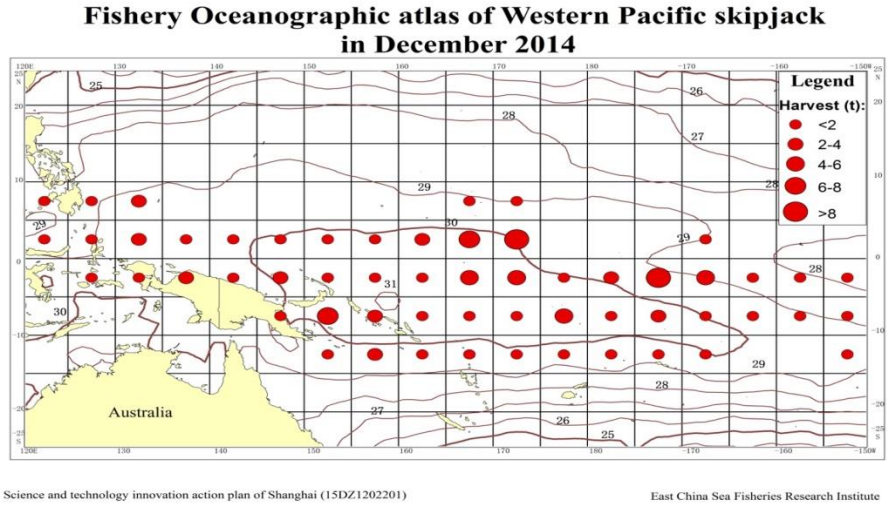

Figure.2. Fishery Oceanographic atlas of Western Pacific skipjack in December 2014

Finally, ArcPy calls the cartographic module to realize the automatic preservation and output of fisheries oceanographic map. The key to automatic preservation and output is layers traversal, traversing the marine environment data and fishery resource data, and simultaneously displaying and saving .mxd files for matching data on time series. The format of .mxd file should be saved as relative path for subsequent analysis, and output can be stored as JPEG, PDF and other formats as needed.

In this paper, 15 years Fishery Oceanographic atlas of Western Pacific skipjack were mapping monthly from 2000-2014. By using IDL to read the data of marine environment grid data in NC format, and using ASCIIToRaster_conversion and Contour methods of ArcPy to convert, read and generate contours of sea surface temperature data in batches; By using ArcGIS to query and display the fishery resource data in timing matching, and adding the processed sea surface temperature data and fishery resource data as two layers, render the layer and batch output.

4. Conclusion

The fisheries oceanographic atlas is conducive to guiding scientific fishing vessels, while improving the efficiency and ensuring the safety of fishery operation. The cartographic elements of fisheries oceanographic atlas include marine environment data, fishery resource data, reference map and finishing elements, among which marine environment data and fishery resource data are often used as the basic oceanographic elements of fishery state map. The categories of marine environment data include sea surface temperature, sea surface height, chlorophyll concentration, current and other marine environmental data. Based on Python access to ArcGIS modules, functions and classes, we can realize the automation of data processing and mapping in the field of marine fishery, which improves the efficiency of cartography and changes the repetitive complexity of traditional cartographic methods. Meanwhile, this paper takes Fishery Oceanographic atlas of Western Pacific skipjack as a case study based on ArcPy automatic cartographic technology, has high transitivity, can be used in other thematic map production field, for future research to provide reference. The ArcPy automatic cartographic technology based on Fishery Oceanographic atlas of Western Pacific skipjack as a case study has high transitivity and can be applied to other fields of thematic map production, which will provide reference for future research simultaneously.

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