A National Oceanographic Partnership Program Award

The FishNet Distributed Information System

E. O. Wiley
Natural History Museum and Biodiversity Research Center
The University of Kansas, Lawrence, KS 66045-7561 USA
Phone: (785) 864-4038 FAX: (785) 864-5335 E-mail: ewiley@ku.edu

A. Townsend Peterson
Natural History Museum and Biodiversity Research Center
The University of Kansas, Lawrence, KS 66045-7561 USA
Phone: (785) 864-9526 FAX: (785) 864-5335 E-mail: town@ku.edu

C. Richard Robins
Natural History Museum and Biodiversity Research Center
The University of Kansas, Lawrence, KS 66045-7561 USA
Phone: (785) 864-4594 FAX: (785) 864-5335 E-mail: Crr@ku.edu

David A. Vieglais
Natural History Museum and Biodiversity Research Center
The University of Kansas, Lawrence, KS 66045-7561 USA
Phone: (785) 864-4038 FAX: (785) 864-5335 E-mail: vieglais@ku.edu

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Internet Site: http://www.speciesanalyst.net/fishnet/

Long-term goals

FishNet is designed as a distributed information system to furnish biodiversity information from natural history museums to anyone with Internet access. The goals were to demonstrate that this could be accomplished, if the data could be served in a consistent and timely manner, and to demonstrate that the data could be used to conduct significant scientific research.

Objectives

The first objective was to demonstrate that Z39.50 and XML protocols could be used to implement the query system and that the system could operate on a worldwide basis with databases using different platforms. The second objective was to demonstrate that useful scientific research could be performed using the data obtained through the FishNet distributed information system.

Approach and work plan

Our database programmer, Joel Kolatch, implements FishNet at partner institutions. Vieglais establishes protocols for *The Species Analyst* (TSA: http://tsadev.speciesanalyst.net/Z.X/). Kolatch orders servers and performs the necessary programming to link partner institution databases or he assists Information Technology personnel at partner institutions in installing the necessary programs. The PIs, in concert with the graduate research assistant, Kristina McNyset,

uses the desktop version of the Genetic Algorithm for Rule-set Prediction (GARP) to perform ecological forecasting studies on marine fishes to demonstrate the scientific potential of the data obtained through the FishNet partnership, as detailed below.

Work Completed

For the first objective, 22 of 25 partner institutions are on-line as of 20 January 2003 (http://habanero.nhm.ukans.edu/zportal/tsasimple.asp) and one institution (Philadelphia Academy of Science) is scheduled to be on-line by March 2003. Two institutions (Smithsonian and Australian Museum) could not be connected to the system due to technical incompatibilities of their proprietary database systems. They will be connected when the implementation of a DiGIR query system is in place. (DiGIR operates using pure XML protocols.) The results are reported in Vieglais et al. (2000). The second objective, demonstration of useful scientific research, is ongoing. We have one marine research paper that has been accepted pending revision (Wiley et al.). We have also used FishNet to perform two studies on freshwater fishes that are in various stages of revision pending provisional acceptance (McNyset et al., and Iguchi et al.)

Results

We have demonstrated that specimen data for marine biodiversity studies can be acquired from natural history database resources scattered throughout the world in a timely manner. For example, searching for the records of a single species among millions of records in 24 different museum databases and downloading the total results in a common format takes less than two minutes (Vieglais et al., 2000). A demonstration proof-of-concept study that addresses the second objective is attached to this report. An amended version of this manuscript is being finalized for publication in *Oceanography* (Wiley et al.). In summary: specimen data were collected from FishNet partners using The Species Analyst representing 18 species of littoral and benthic species of fishes inhabiting the Central Western Atlantic Ocean, the Caribbean Ocean, and the Gulf of Mexico. Specimen data were analyzed in concert with environmental data from the World Ocean Atlas in a machine-learning environment provided by the genetic algorithm GARP. GARP yields an ecological niche model. The models were projected in a GIS environment onto the region, yielding a prediction of where the niche models were realized in geographic space. The accuracy of each model was tested with specimen data that was withheld from building the niche model. In every species, the intersecting subset 10-best niche models were found to be accurate and statistically significant. We are submitting a grant to the National Science Foundation proposing to expand this study. An example of one such model set is shown in Figure 1.

Impact and applications

National Security

The ability of GARP to perform ecological forecasting using existing biodiversity databases (such as FishNet) is of immense potential value to national security interests. For example, Peterson is now using GARP and existing databases to study disease vectors and modeling the spread of the Nile virus.

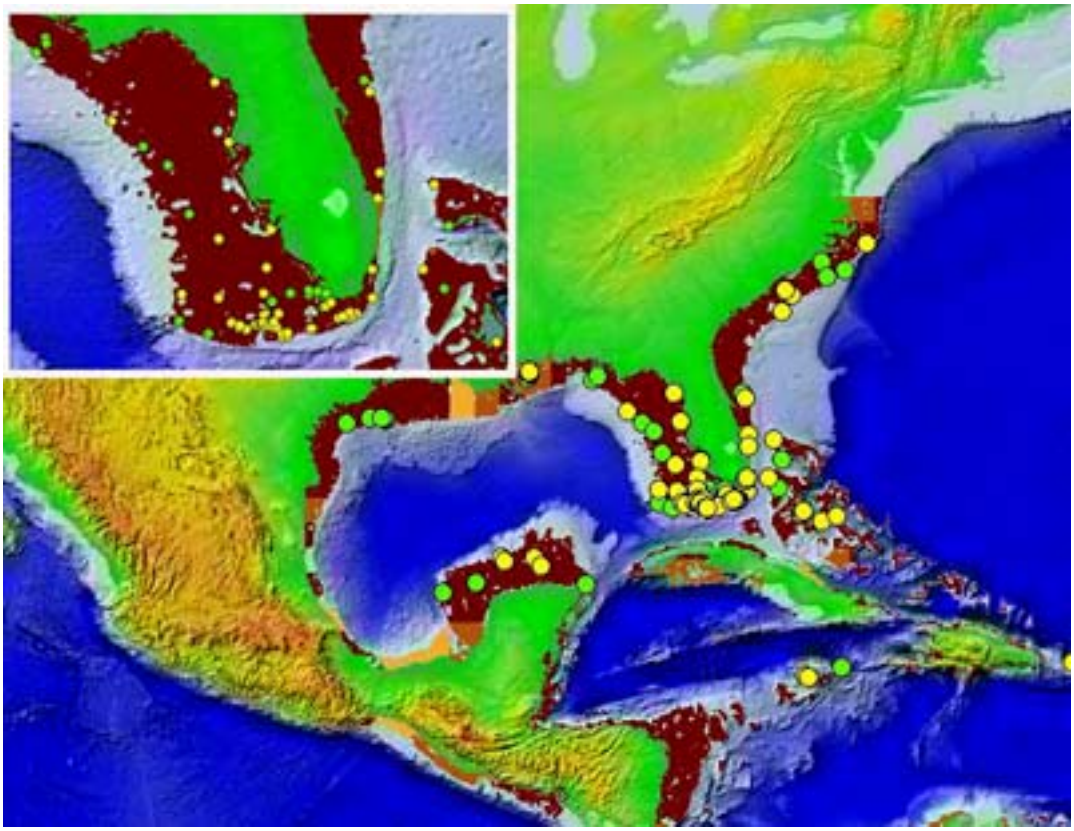

Figure 1. Prediction of geographic distribution of the teleost fish *Monacanthus ciliatus* in the Central Atlantic, Caribbean, and Gulf of Mexico using GARP. Yellow dots are point localities used by GARP in concert with nine WOA 98 environmental surface coverages and bathymetry. Green dots are point localities withheld from modeling and used to test the prediction. Blue denotes bathymetric depth, with lighter blue indicating relatively shallow waters. Tan to dark brown shading denote numbers of model intersections: tan 5-6; rust: 7-9; dark brown, 10 intersections respectively. The inset shows details off Florida and parts of the Bahamas (from: Wiley et al. accepted pending revision).

Economic Development

Just as with the potential for our system to provide information of interest to National Security, so it has the potential to provide information on economic development. For example, data from FishNet (especially if FishNet is more widely implemented) can be used to track changes in distributional patterns of marine organisms and to model the niches and predict the geographic distributions of economically important marine fishes. In the terrestrial world such implementation is ongoing.

Quality of Life

We are now using FishNet data in concert with GARP technology to model invasive species. Preliminary modeling of the invasive species *Pterois volitans* (a Pacific lionfish, now introduced widely off the Atlantic Coast) in its native habitat is highly accurate (predicts the native range with statistical significance). The projection of the niche model to the Central Western Atlantic Suggests that this species will become widespread throughout the region (Figures 2 and 3, below).

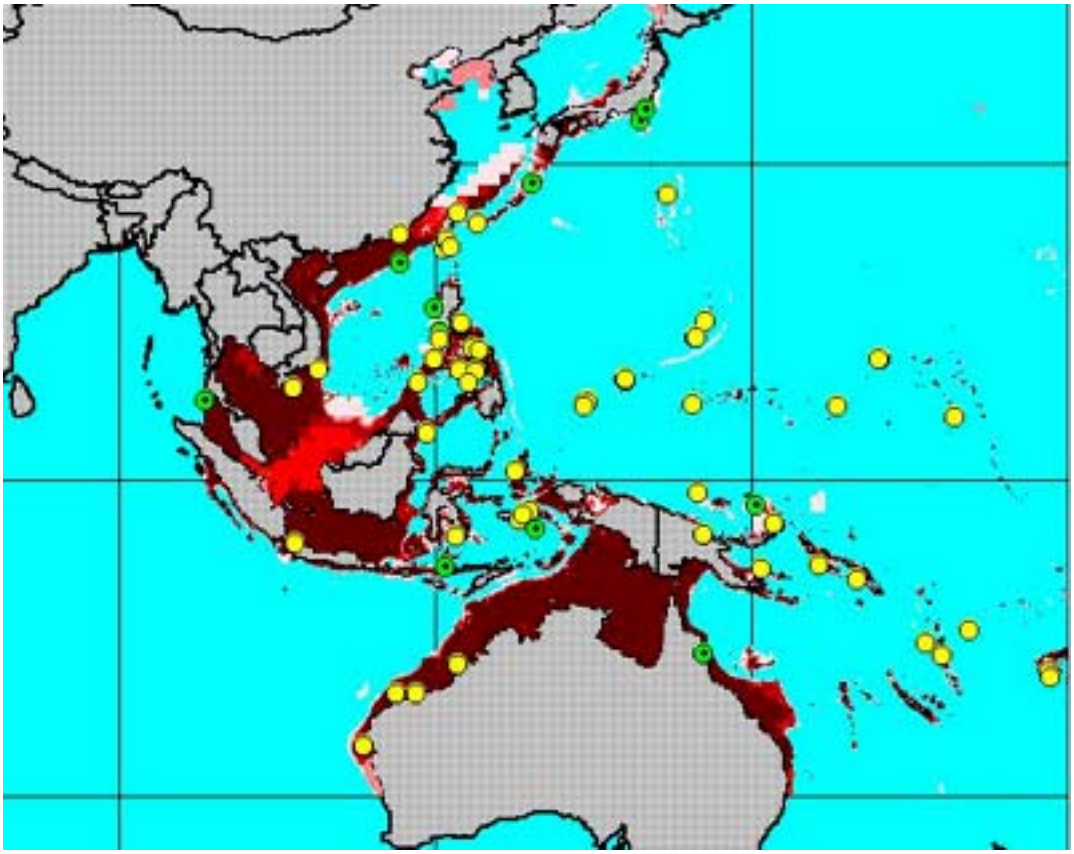

Fig. 2. Prediction of geographic distribution of the teleost fish *Pterois volitans* in the Eastern Pacific Ocean using GARP. Yellow dots are point localities used by GARP in concert with nine WOA 98 environmental surface coverages and bathymetry. Green dots are point localities withheld from modeling and used to test the prediction. Pink to dark red shading denote numbers of model intersections: pink 5-6; red:7-9; dark red, 10 intersections respectively.

FishNet resources are available world wide to any person who has access to the Internet. It allows investigators in developing countries to query specimen data housed in developed countries that were collected the developing countries, effectively repatriating the data to its source for use. Requirements for querying are minimal and within the reach of anyone who has Internet access.

Transitions

Economic Development

PIs Wiley and Peterson have formed a partnership with personnel for USDA National Plant Germplasm Laboratory (team leader: Robert Webster). GARP will be used as part of an overall decision-making matrix to Design an Optimal Seed Distribution Network in Afghanistan. The proposal was submitted by Webster to the International Center for Agricultural Research in the Dry Areas (ICARDA) in November, 2002.

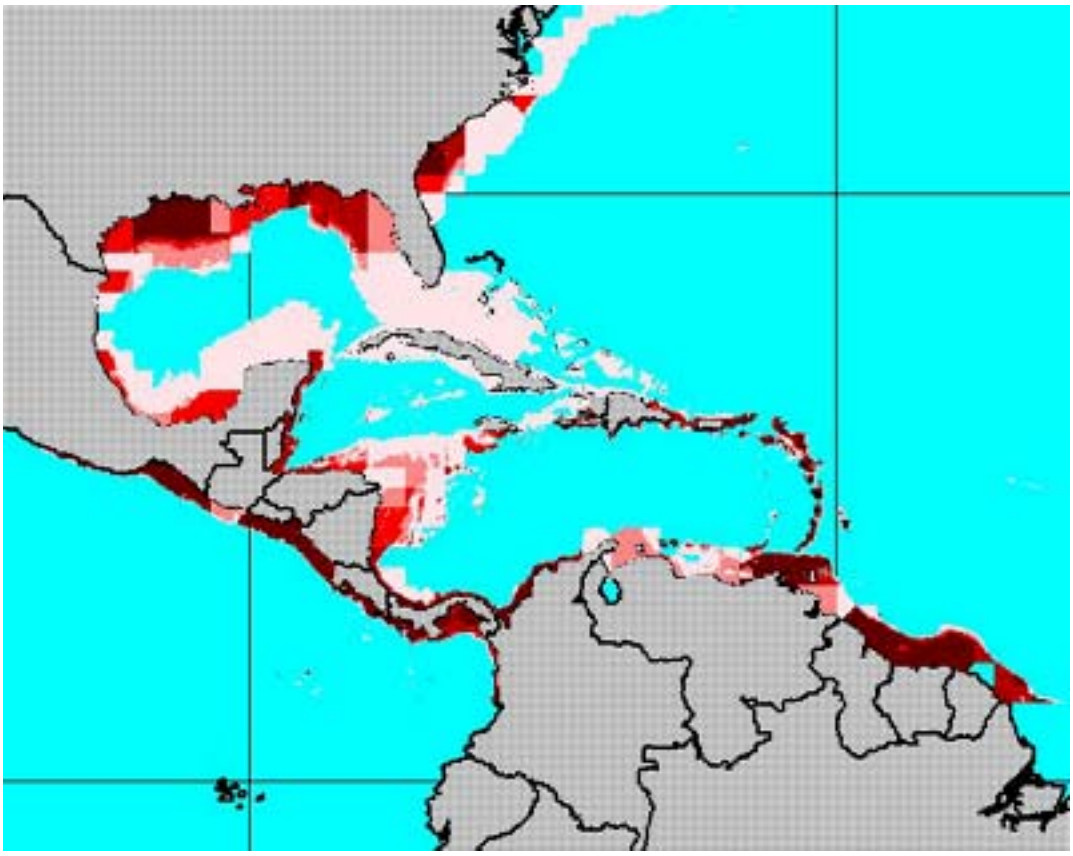

Fig. 3. Prediction of geographic distribution of the teleost fish *Pterois volitans* in the Central Western Atlantic Ocean region using GARP and based on the ecological model in the native range of the species. Pink to dark red shading denote numbers of model intersections: pink 5-6; red:7-9; dark red, 10 intersections respectively.

Quality of Life

PIs Wiley, Paterson and Robins have formed a partnership with the Nonindigenous Aquatic Species Program, USGS Center for Aquatic Resource Studies (James Williams, team leader) to model the distributions of potential invasive aquatic species for the purpose of accessing potential threats to both marine and freshwater environments of the U.S.

Science Education and Communication

FishNet is now being used as a major resource for accessing fish distributional data by ichthyologists.

Related projects

See above.

References

Primary technical literature regarding FishNet, GARP and Ecological forecasting can be found in Vieglais et al. (2000) and Kristalka et al. (2002), cited below.

Publications

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