Interactive Mapping and Dynamic Data Visualization—Eye Candy or Useful Tool for Fisheries Research?

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As researchers, we are constantly reminded that the scientific method begins and ends in observation. The ability to examine information to develop testable hypotheses can become problematic when dealing with large amounts of evolving data that have been collected from diverse locations and numerous organizations over extended periods of time. The addition of potential environmental and biological correlates only complicates the issue. This is especially true for salmon. For example, the North Pacific Anadromous Fish Commission (NPAFC) has over 60 years of disk and archival tag recovery data from salmon and steelhead collected on the high seas of the North Pacific. As of 2018, this dataset contains information from over 18,000 tag releases and recoveries. Similarly, temporal and spatial data associated with decades of coded-wire tag and marked otolith recoveries from salmon fisheries exist throughout the Pacific Rim. How can all this information be combined with variables such as sea surface temperature, current regimes, and chlorophyll concentrations within a temporal context over broad geographic scales in a way that helps to formulate questions, develop hypotheses, and address management concerns? By presenting large complex data sets in a dynamic format, such as an interactive map, users can easily visualize and manipulate large amounts relational data to look for patterns and correlations. Displaying data with potential correlates in a temporal context can be used to determine how patterns and relationships change over time. For salmon, decades of tag recovery information can be combined with a variety of potential environmental correlates and mapped together to create customized time-enabled dynamic displays of movement. Such mapping can provide insight into their ocean distribution and migration patterns relative to seasonal and long-term environmental change. Interactive maps help to visualize almost any kind of data while also fostering data sharing and collaborative research, providing tools to support future research and analyses, and promoting public outreach. Although these analyses are descriptive in nature, they can be used to develop hypotheses and questions to which more quantitative and statistical approaches can be applied.

In an effort to efficiently examine six decades of information contained within the NPAFC's high seas salmonid tag recovery database, the Alaska Department of Fish and Game (ADF&G), in collaboration with the NPAFC's Working Group of Salmon Marking, is developing an online Interactive Mapping System (IMS) that will allow users to visualize and study the ocean distribution and movement patterns of Pacific salmon and steelhead trout over space and time by dynamically mapping tag recoveries against a variety of environmental factors such as sea surface temperature, chlorophyll, and climate indices.

Fig. 1. Prototype Interactive Map displaying Pacific salmon high seas recoveries and releases (1956–2015), as well as average sea surface temperatures. Grey, dark orange, dark blue, dark purple, and dark yellow represent releases of tagged Chinook, chum, coho, sockeye, and pink, respectively. White, light orange, light blue, light purple, and light yellow represent recoveries of tagged Chinook, chum, coho, sockeye, and pink, respectively.

A prototype IMS is has been completed using ArcGIS Pro v. 2.1.2, ArcGIS Online, and Web App-Builder and is currently being tested (Fig. 1). Users can search tag recoveries by tag type, species, age class, and origin to create customized maps of salmon migrations and movement patterns. They can also view recoveries in relation to environmental parameters within a temporal context to visualize how environmental change influences population dynamics over time. Applicable environmental datasets can be downloaded from the internet and incorporated into IMS functionality using the ArcGIS Online application.

Fig. 2. Prototype Interactive Map showing chum salmon high seas recoveries and releases between 2010 and 2016, as well as average chlorophyll a concentrations. The imbedded table displays all the data associated with a specific chum salmon tag release and recovery. Orange dots are releases and yellow dots represent recoveries.

The IMS employs “Smart Mapping” techniques that allows users to symbolize data by species, age class (freshwater and ocean ages), maturity (immature or maturing), sex, geographical origin, and season. Environmental, geographical, and biological data are contained in “layers” that are time-enabled, which allows users to view the progress of releases and recoveries over time in relation to any factors they see fit to view. Release and recovery layers are also “related” at a database level, permitting users to locate and view the release data associated with a unique recovery, and vice versa (Fig. 2). Because users can select and hide layers that contain environmental data (sea surface temperature, chlorophyll, weather patterns, etc.), customized interactive maps can be created to visualize releases, recoveries, and movement pattern in relation to environmental change.

The IMS, as well as individual tag recovery data from the NPAFC High Seas Salmonid Tag Recovery Database, will be available to all users once the final version of the IMS is made public. End users will be able to view, select, and export data directly from the IMS. A test version of the prototype IMS can be found at; <https://adfg.maps.arcgis.com/apps/webappviewer/index.html?id=22efe05eb7fb46349315e9815e793d9a>

The next steps in IMS development include the integration of information from data storage tags to visualize detailed movements and environmental history of individuals, continued data discovery, and IMS customization to make the user interface more intuitive and user friendly.