

**GLDIATR**

Great Lakes Detector of Invasive Aquatics in Trade

**AquaSale**

Lessons from AquaSale: Preparation of the AquaSale database

September 2026

Introduction

During 2024-2025, Great Lakes Commission (GLC) staff directed an outreach campaign to online sellers of target aquatic invasive species (AIS) as part of Phase III the Great Lakes Detector of Aquatic Invasives in Trade (GLDIATR) project (www.glc.org/work/gldiatr). Outreach messages included recommendations for improving online sales pages, including adding notes about shipping restrictions to Great Lakes states and provinces where AIS were regulated. In response, some sellers requested shipping restriction information for all U.S. states or expressed frustration in how difficult it would be to obtain state-by-state regulations for the species they were selling.

Currently, there is no detailed, central repository of laws and regulations governing the sale of plants and animals for every U.S. state. Thus, the GLC GLDIATR team and the National Sea Grant Law Center (NSGLC) partnered to create [AquaSale: A guide to selling and buying aquatic species responsibly](#), a searchable database of restrictions on buying and selling aquatic species released in summer 2026. This online, interactive database enables users to check state laws and regulations to help determine whether their activities comply with state law. Our primary goal in developing this database is to help reduce the spread of AIS through e-commerce. The NSGLC serves as the institutional host of the database and works collaboratively with the GLC and other partners to keep the data up to date.

This report highlights the methods the GLC used to create the database, challenges encountered, lessons learned, and recommendations for those who may be replicating or expanding on this effort.

AquaSale development

The NSGLC provided GLC staff with a list of current invasive species and noxious weed laws to start the process of collating invasive species regulations. From this, we recorded all applicable law information and noted restrictions (e.g., buying, selling, possession, import, export, transport, etc.) for each species we deemed to be “aquatic,” as well as any exemptions or notes related to those restrictions (e.g., permits required, conditions under which restrictions apply, etc.). Our definition of what is aquatic and is included in the

database has changed throughout the data collection process and may continue to change as improvements are made. In the current version of the database (as of September 2026), a plant species was considered to be "aquatic" and included if its wetland indicator status rating on the [U.S. Army Corps National Wetland Plant List](#) was "obligate" or "facultative wetland" in most regions of the United States. Animals were considered "aquatic" if at least one stage of their life was spent primarily in the water. Although we originally compiled data for aquatic mammals and birds, these taxa have been removed from the current version of the database (for more, see next section). After these regulations were compiled, we looked for additional state and federal laws regarding sales of aquatic species, and in cases where state lists featured threatened and endangered species, these laws were included as well but were not obtained for every state. We did not include laws specific to aquaculture or fishing if possible and focused on laws pertaining primarily to the pet trade. Data recorded for each law were then quality checked by a different GLC staff member than the person who compiled the data, and any questions regarding interpretations of regulations were answered by the NSGLC.

A private database application was built using [Saltcorn](#), a no-code application builder and database platform, to input, store, and sort AquaSale data. The structure of the database and underlying data changed several times over the course of the project to accommodate the nuances and variations in state and federal laws, and in consideration to how the final public-facing application would use and display data. The data are organized hierarchically; at the highest level is a state or federal law. Each law can contain one or more sets of restrictions, and each restriction set contains the species subject to those restrictions. For example, State X may have a single invasive species law (one law record) that includes three restriction categories (three restriction records): prohibited species, restricted species, and approved species with no restrictions. Each restriction category contains the associated species, the specific activities regulated (such as possession, purchase, sale, or transport), and any applicable notes, exemptions, or special conditions.

To standardize species names and taxonomic information across all laws, we used standards provided by the [Integrated Taxonomic Information System \(ITIS\)](#). ITIS was also used to acquire lists of alternate common and scientific names as well as taxonomic information such as genus, family, order, etc. When ITIS standards were unavailable for a species, we consulted other taxonomic databases to determine the appropriate common and scientific names, while relying on ITIS to assign the associated taxonomic classification if possible. Compiling taxonomic information allowed us to account for laws that regulate taxa above the species level, such as genera or families. For laws that list a higher-level taxon rather than individual species, we used ITIS to identify all species contained within that taxon. For example, if a law prohibits all members of the family Dreissenidae, species such as zebra mussels and quagga mussels would automatically be considered covered by that restriction, even if they are not explicitly named in the law. To enable users to find applicable restrictions when searching for individual species, we

linked these "downstream" species to the higher-level taxa listed in laws. However, including every single downstream species in a searchable database would have greatly increased its size by adding many thousands of species that users would be unlikely to search for. Therefore, downstream species associated with higher-level taxa were only included in the search function if they were:

1. Already listed elsewhere in the database (i.e., regulated under state or federal law),
2. Listed as species imported into the U.S. as indicated in [United States Fish and Wildlife Service's \(USFWS\) Law Enforcement Management Information System \(LEMIS\)](#) data (available from 2000-2014),
3. Listed in the [Food and Drug Administration's Seafood List](#),
4. Included in lists of common freshwater and saltwater aquarium fish, invertebrates, and amphibians on [Wikipedia.org](#), or
5. Listed as amphibians found for sale by [Edmonds et al. 2026](#).

In addition to being able to search for downstream species to see if any laws regulated them, if a higher-level taxon was searched for, we needed to be able to note whether any taxa within it were restricted and where. For example, if a user searched for the genus *Hypophthalmichthys* (bighead carp), then they should be able to see if any or all species within that genus are restricted (e.g., two species, *Hypophthalmichthys nobilis* and *Hypophthalmichthys molitrix*, are both restricted in Michigan). Reliable and complete downstream taxonomic information was also needed to make this possible. The R package [taxizedb](#) was integral to our data collection process, allowing us to process mass amounts of taxonomic data without having to make API calls to ITIS.gov, which is slow and made difficult due to frequent website outages.

The public facing AquaSale application is an R Shiny app, and significant data processing occurred in R before the data were brought into the app. Restrictions were standardized, consolidating similar regulatory actions into a common set of restriction categories (e.g., multiple actions such as "introduce into public waters," "place," or "plant" were all categorized as "release"). Federal species laws incorporated by reference in state laws were included so that all species covered by those lists were associated with the appropriate state restrictions. Restriction records, species records, and law information were then joined into a single dataset. Additional logic was applied to account for laws that explicitly allow certain species while restricting all others not listed. Native or exempted species were removed where specified by law, and conflicts between overlapping restriction records were resolved. Finally, exemptions, special conditions, and explanatory notes were compiled into standardized public-facing descriptions.

Lessons learned for future database development

One of the greatest challenges of this project was collating disparate laws into a single usable database in a way that captured all the nuances of each law. We designed our database in a way that was flexible enough to handle many different types of restrictions and exemptions, but unfortunately, it cannot accommodate all situations perfectly. In addition, some laws are written in ways that make their inclusion in a standardized database very difficult. Below are key lessons learned from developing AquaSale that may inform future updates and the development of similar databases.

- Researching and collating all state and applicable federal laws takes a significant amount of time to implement, quality check, and keep up to date. A dedicated funding source is needed to update law data at regular intervals to keep information relevant with current rules and regulations.
- When compiling a law's restricted actions, make sure to check their definitions. A restricted action (e.g., "transport") may mean something different in one state's law than it does in another, or a single word may include multiple actions (e.g., "move" = could include "transport," "import," and "release"). "Sell" may also include "offer to sell" in some cases, while in other laws, "offer to sell" is not restricted but "sell" is.
- Confirm definitions of restricted actions with state regulatory or enforcement staff, as their definitions may differ from the classical interpretation of the law.
- Use a versioning system and notes to keep track of structural data changes, decisions about what data to include and why, and application updates. Similarly, keep records of all communications with state regulatory or enforcement staff.
- If expanding upon this work, ideally all regulated species (terrestrial and aquatic) should be included in a single searchable database. We were restricted to compiling regulations only for aquatic species under our organization's mission and funding source, but a comprehensive database would help a broader range of people. In addition, it was difficult to define which species were "aquatic" (especially for plants), and not having a standard definition of this before compiling regulated species lists meant that we may have skipped nebulous species in some state lists.
- If focusing only on aquatic species, determine which species will be classified as "aquatic" ahead of time and stick to those definitions.
- Dealing with taxonomy is time consuming and confusing. Plan to spend a significant amount of time researching taxonomic and scientific naming discrepancies. Using automated scripts to handle naming issues can only do so much.