

**POLICY ANALYSIS OF THE IMPLCATIONS OF CHANGES IN FEDERAL
AUTHORITY UNDER THE LACEY ACT TO PROHIBIT INTERSTATE MOVEMENT
OF INJURIOUS WILDLIFE**

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Cooperating Scientists:

University of Florida.....	Dr. Jeffrey Hill (Project Leader) Dr. Quenton Tuckett
Louisiana State University.....	Dr. Greg Lutz Dr. Christopher Green
University of Tennessee.....	Dr. J. Brian Alford
Virginia Tech University.....	Dr. Carole Engle Dr. Johnathan van Senten

Project Objectives:

- 1) Explore the range of options available for states to evaluate the risks associated with permitting the transport of non-native species across state lines within the contiguous United States and how each state currently regulates these species.

Subobjective 1A: Current state practices and regulation of non-native fish and aquatic species (including interstate movement)

Subobjective 1B: Potential policy/regulatory options for states to allow movement of non-native fish and aquatic species across state lines.

Subobjective 1C: Risk screening and risk assessment tools available for support of decisions regarding policy/regulation of non-native fish and aquatic species and their interstate movement

- 2) Compare and contrast the strengths and weaknesses of each option identified from Objective 1 and analyze the regulatory implications for southern regional aquaculture across the range of policy approaches.

Subobjective 2A: Strengths and weaknesses of policy/regulatory options

Subobjective 2B: Implications to southern regional aquaculture of policy/regulatory options

- 3) Provide a management recommendation to the states in the southern region based on the outcomes of Objectives 1 and 2.

Anticipated Benefits

Due to changes in interpretation of the Lacey Act following a recent court ruling, the regulatory environment for the trade in live aquaculture organisms grown in the southern region could shift for important markets. This research will bring clarity to how states plan to respond to these Lacey Act changes, including any anticipated regulatory changes impacting southern region aquaculture. Focus was placed on the trade in live fish/crawfish and other aquatic organisms, where prohibitions, or adoption of U.S. Fish and Wildlife Service (USFWS) approaches and tools could lead to unwarranted prohibitions and lost markets. Identifying anticipated changes at the state level, the strengths and weaknesses (economic, environmental, and sociological) of these and other identified policy/regulatory approaches, can provide clarity to producers. Results will be disseminated to stakeholders so that they can remain informed of regulatory changes and further disseminated to the states so that they can make informed regulatory decisions.

Progress and Principal Accomplishments

Objective 1: Explore the range of options available for states to evaluate the risks associated with permitting the transport of non-native species across state lines within the contiguous United States and how each state currently regulates these species.

Under provisions of the Lacey Act, the USFWS not only regulated the importation of injurious wildlife into the United States and its territories, but it was also further interpreted since the 1960s as banning interstate movement within the continental United States. Following a challenge by the U.S. Association of Reptile Keepers, the U.S. Court of Appeals for the District of Columbia on April 7, 2017 affirmed a lower court ruling that the government lacks authority to regulate shipment of injurious species across state lines (see Hill et al. 2018). This ruling has been interpreted as a positive development for southern region aquaculture (Hill et al. 2018) but could also lead to an increasing patchwork of regulation at a time when the broader U.S. already exhibits over 1,300 laws (Engle and Stone 2013). Agencies in many states are now reviewing their exposure to risk of invasive species and examining policy and regulatory changes. Depending on the outcome of state agency decisions, southern regional aquaculture may be impacted either in producing states within the region or in states (inside or outside of the region) with important markets for southern aquaculture products. Upon completion of Objective 1, we will have identified practices currently in place and the range of options for regulating and evaluating the risks of non-native species transport across state lines. This is the necessary first step prior to evaluating the strengths and weaknesses of each approach and the regulatory and economic implications for southern regional aquaculture.

Subobjective 1A: Current state practices and regulation of non-native fish and aquatic species (including interstate movement)

Regulations of states within the southern region and of states which contain important markets for live aquaculture products from the southern region all have a bearing on the potential effects of regulation on southern regional aquaculture. A list of states that are important markets for southern aquaculture will be developed using existing economic data and models (van Senten and Engle 2017). All states in the southern region and all large market states outside of the

southern region will be canvassed to determine current policy/regulation on non-native fish/crawfish and other aquatic species, including interstate movement.

In order to identify the range of policy options available, in response to changes to the Lacey Act, we first identified the current state practices and regulations for states represented by the Southern Regional Aquaculture Center and more broadly across the U.S., including important markets for aquaculture products grown in the southern region. We used a combination of internet searches of state statutes and administrative code and a formal phone survey with a standardized questionnaire to identify current regulatory practices. The phone survey was directed to state Aquatic Nuisance Species coordinators (ANS coordinators), as it was expected they would be most knowledgeable about current regulatory practices and any state regulatory responses to Lacey Act changes. If a ANS coordinator was not available, or one was not on staff, we talked with a knowledgeable representative, often the state representative to their respective Aquatic Nuisance Species Task Force regional panel.

The survey was organized into three main sections and included 11 primary and 8 follow up questions. The first section (and questions therein) was designed to gather background information on regulation of non-native aquatic species. Specifically, this first section was used to determine where authority resides (i.e., the specific state agency), the regulations which govern possession, production, transportation, and sale of non-native aquatic species, and whether the state maintains a list of regulated non-native aquatic species (Table 1). The second section of the questionnaire was used to evaluate decision making. Specific questions were related to the presence/absence of standardized procedures for evaluating risk, the utilization of risk screens and risk assessment, the amount of stakeholder involvement, use of formal risk management, presence of non-native and invasive species specialists, the overall decision-making process. The final section of the questionnaire was directed at determining how the states have responded to Lacey Act changes, particularly whether changes have been made, if changes are planned, and whether the state has plans to harmonize the state list with the Injurious Wildlife list. After drafting the questionnaire, and prior to contacting state agency representatives, project staff acquired Institutional Review Board (IRB) approval through the University of Florida (UF) to ensure the welfare and rights of research participants (<http://irb.ufl.edu/>).

Specific contact people, often Aquatic Nuisance Species coordinators (hereafter ANS coordinators), were identified in each state using the project investigators' professional contacts and state representatives appointed to various regional panels of the federal Aquatic Nuisance Species Task Force (e.g., Gulf and South Atlantic Regional Panel; (ANSTF; <https://www.anstaskforce.gov/default.php>)). ANS coordinators were contacted, first by email, beginning on December 7, 2020. Follow up emails were sent and phone calls were made approximately every two weeks until March 24, 2021. In order to harmonize data collection, a single investigator queried agency representatives regarding current state practices and regulation. The single investigator completed all surveys of state ANS coordinators over approximately 16 weeks. Prior to conducting the survey, ANS coordinators were read an informed consent statement which was approved by the UF IRB (Fig. 1).

In total, surveys were completed for 47 ANS coordinators. Representatives of Connecticut, Maryland, and Massachusetts did not return surveys and we were not able to coordinate interviews. State practices were determined through questionnaires and these phone surveys

lasted between 16 and 54 minutes (mean = 31.99; SD = 11.04). Three ANS coordinators requested questions to be sent to be filled out; thus, no time estimates are available. ANS coordinators noted the state institution responsible for regulation of non-native aquatic species primarily fell to the state department responsible for regulation and management of game and fish (46 out of 47 states). However, 17 (36%) of ANS coordinators also indicated the state department responsible for regulating agriculture was also involved, typically when species are raised commercially in aquaculture. Additional agencies with regulatory authority were also noted, including those responsible for regulation and management of marine resources. Current state practices and regulation of non-native fish and aquatic often fell under multiple state statutes and these regulations were also sometimes included in administrative rules where authority for prohibiting species was delegated to agencies by state statute.

ANS coordinators identified several regulatory approaches to the possession of non-native species. However, ANS coordinators rarely mentioned transportation and sale. One exception was Florida, which separates possession from transport due to importation to large commercial hubs. State regulation of possession typically followed two approaches: allowed list (i.e., clean list) and a prohibited list (i.e., prohibited list). Several states used a combination of the two (Fig. 2) and approximately half of all responding states included conditions for the possession of certain species (permitted). Four state ANS coordinators specifically mentioned carve outs for ornamental species. State ANS coordinators indicated, almost universally, that the list of prohibited species was available online at agency websites. In addition to agency websites, prohibited species lists were also maintained online in state code and administrative rule.

Both regulatory approaches, prohibited ('dirty list') and allowable ("clean list"), have their drawbacks. For example, it may take years for a species to be added to a prohibited list, especially if prohibition requires addition to a list by state statute. Prohibited lists also tend to be reactive, only prohibiting species after they have become invasive (but see Jewell and Fuller 2021 for federal lists and numerous examples in Florida such as Hardin and Hill 2012 for Barramundi *Lates calcarifer* and Hill and Lawson 2015 for Arapaima *A. gigas*). In contrast, allowable (clean) lists may lead to unwarranted economic losses and place unnecessary burdens on managers to evaluate risks for a large number of species, particularly for ornamental species, where hundreds of species and varieties are reared and traded (Hill and Yanong 2016).

In response to questions pertaining to Lacey Act changes, seven states specifically called for greater enforcement of existing USFWS regulations, including inspection and enforcement of commercial haulers and personal watercraft. Six of the seven states are members of the Western Regional Panel on Aquatic Nuisance Species; the other state was a member of the Great Lakes Panel. Further, four states (scattered across the U.S.) indicated they did not rely on the Lacey Act for protection from invasive species. Most state coordinators indicated that no changes have been made following the ruling on the Lacey Act (Table 2; Fig. 3). Nine state coordinators indicated they are assessing the impact of Lacey Act changes on their state. Three states added species in response to the Lacey Act changes and one state harmonized the state list with the Injurious Wildlife list (Table 2). Ultimately, few changes have been made in response to the changes in Federal authority.

Attached Appendix lists regulated species by state and indicates species used in southern regional aquaculture.

Subobjective 1B: Potential policy/regulatory options for states to allow movement of non-native fish and aquatic species across state lines.

We used information from Subobjective 1A, including the questionnaire in Table 1, to identify the range of potential policy/regulatory options. In addition to the questionnaire, project staff examined state regulations (using web searches) pertaining to the possession and sale of non-native aquatic species for all 50 states, and not just the states that were contacted as part of the questionnaire. Specific questions which informed the range of policy options included question 3 (current regulatory environment) and 10 (responses to Lacey Act changes). Project staff also considered additional policies and regulations for known or possible practices which that were not identified during the survey.

While states did not often separately regulate possession from movement across state lines, project staff identified several policy and regulatory responses to the movement of non-native aquatic species across state lines. These options, predominantly, were those that limited possession. Three options were identified during the survey: 1) evaluate species singularly, 2) harmonize the state list of prohibited species with neighboring states, and 3) harmonize the state list of prohibited species with the Injurious Wildlife list. Each option has strengths and weaknesses (Table 3). One option that was explicit throughout the survey process was that states would do what was in their best interest, often indicating they use a blended approach to regulation. This included evaluation of the USFWS Injurious Wildlife list, evaluating prohibited species lists of neighboring states, and horizon scanning of potential threats.

Subobjective 1C. Risk screening and risk assessment tools available for support of decisions regarding policy/regulation of non-native fish and aquatic species and their interstate movement

Project staff used the questionnaire developed under subobjective 1A to determine the range of risk screening and risk assessment tools used by the surveyed states. In addition to the risk screening and risk assessment tools identified by the questionnaire, we used a literature review to identify the range of available options. This literature review considered additional tools, including the Ecological Risk Screening Summaries and associated tools (Marcot et al. 2019), Fish Invasiveness Screening Kit (Copp et al. 2009, Lawson et al. 2013), Aquatic Species Invasiveness Screening Kit (Copp et al. 2016), Generic Nonindigenous Aquatic Organisms Risk Analysis Review Process (Generic Analysis; ANSTF 1996), Regulatory System for Non-Native Species used in New York (https://www.dec.ny.gov/docs/lands_forests_pdf/invasive062910.pdf), National Oceanographic and Atmospheric Association, Great Lakes Aquatic Nonindigenous Species Information System (NOAA GLANSIS; Fusaro et al. 2016), Science-Based Tools for Assessing Invasion Risk (Howeth et al. 2016), and the National Detailed-Level Risk Assessment Guidelines: Assessing the Biological Risk of Aquatic Invasive Species in Canada (Mandrak et al. 2012). Additional studies are available which rely on species traits, evaluation of pathways of introduction, and/or characteristics of the receiving system, which are often specific to one species (or set of species) or to a particular region; these analyses were not considered here. This list of tools may not be exhaustive; instead, we have included most of the well-known tools identified in other analyses (<https://www.glerl.noaa.gov/glansis/raExplorer.html>). Ultimately, including tools which were not specifically mentioned in the questionnaire (Question 4 and sub-questions) allowed the most complete recommendations on adopting risk-based tools and their characteristics.

When surveyed, ANS coordinators most often indicated there was no standardized procedure for evaluating risk (n = 32). Thirteen states utilized a standardized procedure; two additional states indicated there was a common process, but this process was not standardized, or it was only applied to select species (e.g., zebra and quagga mussels). When asked if these procedures could change, 31 state ANS coordinators indicate there were no current plans to change or adopt a process. However, 16 states indicated there was interest in changing or adopting a process. State coordinators more often than not indicated a tool was used to assess risk (25 states), 21 indicated a tool (or available outputs) were not utilized; one coordinator was not aware, but ultimately not sure if tools were utilized. Most states indicated that a single tool was used (80%; n = 20); two states indicated two tools were used and three states indicated three tools were used. State ANS coordinators often indicated that species are evaluated on a case-by-case basis and information from a variety of sources is then evaluated. Further, many state coordinators indicated there is a process for plants, but one is not available for animals. Tools that were identified by ANS coordinators (total mentions) included Ecological Risk Screening Summaries (most often indicated; Fig. 5), followed by unknown or an in-house tool, Aquatic Species Invasiveness Screening Kit, Early Detection Rapid Response (EDRR), which could also be classified as risk management, Fish Invasiveness Screening Kit, and others such as the Generic Analysis, GLANSIS, and Hazard Analysis Critical Control Point (HACCP: USFWS 2015, Hill and Tuckett 2018), a process that also includes elements of risk management. Several of the tools mentioned, Climatch, habitat suitability, Flood and Storm Tracker Maps (FaST; <https://nas.er.usgs.gov/viewer/Flooding/>), and others, could be considered part of an overall risk assessment process, and were not contrasted.

Project staff evaluated and classified the identified tools according to several broad categories, including the risk approach, the information inputs, and the information outputs. Several subcategories were also evaluated under these broad categories. Several risk tools were identified (Table 4), including tools that can be variously classified (e.g., risk screens, risk assessments) depending upon their rigor and focus. Risk tools utilized a variety of approaches to evaluating risk, probabilistic, semi-quantitative; qualitative, and classification based. Both quantitative and qualitative processes can be useful, although, there could be the assumption that quantitative assessments are best, but this assumption is confronted by limited data and the extensive effort. Almost universally, risk tools utilized expert opinion. Taxa coverage by the various tools varies, but most cover fish, and most provide coverage to aquaculture products and hybrids.

One concern with risk tools is the scale of analysis; risk is regional and adopted tools should be scalable to the risk assessment area (Hill et al. 2018). This is a concern because risk of aquaculture products to regions outside the southern region and more broadly to the U.S. could skew perceptions of risk and cause unwarranted prohibitions. Several tools, FISK, AS-ISK, Generic Analysis, and the Regulatory System for Non-Native Species are scalable to the risk assessment region. One notable exception is the ERSS, which is completed for the entire U.S. (Hill et al. 2020). Data inputs among risk tools are largely similar because the majority of tools examine establishment, spread, and ecological impact using propagule pressure, climate matching/suitability, and prior invasion history (establishment and impacts in other regions). Of particular concern to southern region aquaculture, risk tools differ in their consideration of socioeconomic benefits and contrasts between benefits and risks (Table 4). Risk-benefit analysis is not considered a necessary component of risk assessment (Roy et al. 2018). However, consideration of benefits is a necessary aspect of risk management (Hill and Zajicek 2007). Just

two tools, the Regulatory System for Non-Native Species and NOAA GLANSIS explicitly examine regulatory impact.

Risk screening and assessment tools are paired with formal risk management to achieve comprehensive risk analysis (Hill and Zajicek 2007). Risk management or a structured decision-making process can be applied before or after entry of a potentially invasive species (Maguire 2004). In Question 6 of the survey project staff asked: “Does your state employ a formal risk management process”? This was followed up with asking the ANS coordinator to identify the process. ANS coordinators mentioned particular species and practices, but rarely a comprehensive and formal approach. For example, states managed risks through inspection of aquaculture facilities or through detection of high priority non-native species (Asian carps; zebra and quagga mussels), which then triggered a management response. States that are located west of the 100th Meridian typically mentioned management responses and preventative practices (i.e., boat inspections) focused on zebra and quagga mussels. These management responses, beyond the Asian carps, which may be present as contaminants of other aquaculture products (e.g., grass carp), appear unlikely to affect commercial activity of the majority of southern region products.

While risk management is often considered separate from risk assessment process, this separation could decrease connections between considerations of values along with consideration of risks (Hill and Zajicek 2007), and ultimately a disconnect between social values and scientific knowledge (Maguire 2004). Though supported by the finding that benefits were rarely considered in the formal tools we evaluated, the majority of tools identified in the study were focused on risk screening or assessment rather than risk management. Of the nine tools assessed, only the Generic Analysis, NOAA GLANSIS and New York’s Regulatory System for Non-Native Species specifically considered species benefits (Table 4). Further, ANS coordinators also mentioned utilizing EDRR and Hazard Analysis Critical Control Point (HACCP), tools or processes which include components of risk management. ANS coordinators were also surveyed to determine if a state has aquatic invasive species specialists that aid in evaluating risk (Question 8). Typically, staff size was small, and some states did not have ANS coordinators (some of the smaller states). However, there were notable exceptions in the Midwest, West Coast, and Florida. The lack of specialists could partly explain why many states lacked an overall decision-making process (Question 9), or at least one that was codified.

Stakeholders were involved in some states at various levels in the risk assessment and risk management process, but most often after the decision-making process has been concluded. Most typically, this was during the rule making process where public comments are solicited. That said, six states indicated that stakeholder group representatives (e.g., nursery and aquaculture groups) were included on invasive species councils, which would also include state agency representatives and often environmental NGOs. However, we were unable to determine the extent to which these invasive species councils affected policy and regulation. Several states indicated that specific trade groups would be contacted during the decision-making process if the ultimate decision making could potentially affect the identified industry. In addition to the information reported by the ANS coordinators, just one risk assessment tool typically includes stakeholder involvement, the Generic Analysis. Implementation of this tool often includes one or more expert stakeholder panels involved in risk assessment and risk management (e.g., Hardin and Hill 2012). While the New York Regulatory System for Non-Native Species could include a knowledgeable stakeholder (e.g., aquaculturists), this does not appear to be required.

Objective 2: Compare and contrast the strengths and weaknesses of each option identified from Objective 1 and analyze the regulatory implications for southern regional aquaculture across the range of policy approaches.

Subobjective 2A. Strengths and weaknesses of policy/regulatory options

Policy/regulatory options were identified in Objective 1, which were subsequently analyzed to determine the complex mosaic of strengths and weaknesses to each approach. The goal was to identify how each approach balanced environmental protection and reasonable economic activity. Project investigators analyzed these options for their strengths and weaknesses, categorizing them, and demonstrating where the net balance lies. Policy and regulation options were first categorized by their focus, including options focused on possession (most states), transport (often conflated with possession), and release. Beyond the policy and regulatory focus of each option, the following criteria were considered when analyzing the strengths and weaknesses: 1) effects on economic activity, 2) state resources required, including invasive species specialists, 3) ease of enforcement, 4) scale of the regulation (i.e., is risk of invasion identified at the appropriate geographic scale), and 5) prevention of escape and release.

Project staff identified eight policy/regulatory options focused on possession, three focused on transport, and two focused on release. These options are not mutually exclusive and could, in many circumstances, be implemented simultaneously (Table 3). For those focused on possession, three options, two of which were identified during the survey, harmonize state prohibited lists with neighboring states and prohibit on a case-by-case basis, exhibit an appropriate balance between the five criteria we established. The third option, harmonize state prohibited lists according to bioclimatic regions, is partially encapsulated by harmonizing with neighboring states, at least for those states that are climatically homogenous and similar. Two of the three options focused on transport, transport by permit only, and prohibit non-native species transport; each increase the regulatory burden on states and were not identified during the survey. For options focused on release, universally, state laws prohibit the release of non-native species, and education and outreach are emphasized. Throughout the survey, ANS coordinators would often note that an education and outreach component is a large part of the overall ANS program.

Subobjective 2B. Implications to southern regional aquaculture of policy/regulatory options

Policy/regulatory options can have profoundly different implications for southern regional aquaculture industries. Project investigators will assess the implications of policy and regulatory options identified in Subobjective 2A in terms of overall trade (volume and the types of species), potential for decline/growth, and economic effects. We limited our analysis to a subset of options, particularly those that were noted during the survey and those that could, on balance, be better options for both overall trade and environmental protection. As above, we assessed each option relative to its 1) effects on economic activity, 2) state resources required, including invasive species specialists, 3) ease of enforcement, 4) scale of the regulation (i.e., is risk of invasion identified at the appropriate geographic scale), and 5) prevention of escape and release.

Of the four policy/regulatory options evaluated, coordinating with neighboring states and regions, harmonizing lists as warranted, exhibits the appropriate balance of economic activity and environmental protection (Table 5). Overall, policy/regulatory options were largely variable

in terms of economic activity. This suggests that options must include a specific focus on species impacted by the Lacey Act changes, particularly the cyprinids.

Currently, southern regional aquaculture industries are affected most by the inclusion of Asian carps (Bighead Carp *Hypophthalmichthys nobilis*, Silver Carp *H. molitrix*, and Black Carp *Mylopharyngodon piceus*) on the current Injurious Wildlife list. These species have been produced in southern regional aquaculture facilities and Black Carp has been used as a biological control for snails to facilitate disease management in catfish ponds and other aquaculture commodities. The legal ability to move these across state lines again makes these species more available to aquaculturists, though a certain stigma is still associated with these species as invasives, particularly the two bigheaded carps.

Automatic harmonization of state lists with the Injurious Wildlife list as was recently implemented by one state and considered by others is the most threatening management strategy to southern regional aquaculture industries. The uncertain nature of what will be listed by the USFWS in the future is of particular concern (Hill et al. 2018). For example, the Center for Invasive Species Prevention (CISP) petitioned the USFWS in 2016 to list 43 “high risk” species as injurious under the Lacey Act (<https://nivemnic.us/cisp-files-multi-species-listing-petition-with-us-fish-wildlife-service-per-lacey-act/>). These were species rated as high risk using the ERSS tool and published on the USFWS website. The CISP made a compelling argument that listing these species is the logical continuation of federal policy in listing 11 species in 2016 (same result in their risk assessment and why spend the funds if listing such species is not the goal). This list contained 17 fish species and 1 crustacean produced in southern regional aquaculture, including such important species as Blue Catfish *Ictalurus furcatus*, tilapia (Blue Tilapia *Oreochromis aureus*, Mozambique Tilapia *O. mossambicus*, and Nile Tilapia *O. niloticus*), Grass Carp *Ctenopharyngodon idella*, ornamental fish (Common Carp [including Koi] *Cyprinus carpio*, Guppy *Poecilia reticulatus*, and pleco catfishes (four *Pterygoplichthys* spp.)), and Red Swamp Crayfish *Procambarus clarkii*. These species represent sizable commodities in the food fish/shellfish, aquatic weed biocontrol, and ornamental sectors. If these species were listed as petitioned, automatic harmonization would prohibit the movement of these species into any state with this regulatory policy under both state law and Title 16 of the Lacey Act (Hill et al. 2018). Although this petition has not so far been successful, to our knowledge the USFWS also has not denied the petition; in essence, leaving this as a lingering threat to the aquaculture industry. Moreover, the list of high-risk species determined by the ERSS system and published on the USFWS website has greatly expanded, with 135 species currently, including 37 species produced in southern regional aquaculture (https://www.fws.gov/fisheries/ANS/erss_high_risk.html), including additional segments such as pond stocking and mosquito control with species native to the southern region such as Largemouth Bass *Micropterus salmoides*, Redear Sunfish *Lepomis microlophus*, Western Mosquitofish *Gambusia affinis*, and Eastern Mosquitofish *G. holbrooki*.

A number of U.S. aquaculture sectors primarily supply live aquatic animals to customers who purchase these animals either for food, recreational stockings, conservation purposes, or as pets. The Lacey Act has been used in recent years as the basis for a series of violations issued to aquaculture farms in spite of its original intent to prevent the illegal sale of wild animals. In 2017, the D.C. Circuit Court ruled that the Lacey Act can no longer be used by the U.S. Fish and Wildlife Service (USFWS) to prohibit interstate transport of wildlife designated as injurious. This project was developed to gather information on regulatory approaches that may be adopted

by states in response to the 2017 court ruling. States have the option to adopt more stringent regulatory requirements than those of the federal government, and such changes have potential for substantial effects on southern region aquaculture businesses.

The goal of the work done by Virginia Tech University on Subobjective 2b was to assess the implications of potential regulatory actions on southern region aquaculture from the perspective of effects on overall trade (numbers of states affected, volumes of products, species that would be affected), and the potential economic effects.

Approach

Based on a national survey of state regulatory agencies, the project team identified two principal scenarios for analysis of economic impact: 1) effect of a potential decision by USFWS to add the 43 new species included on the petition from the Center for Invasive Species Prevention to the U.S. Department of the Interior to the list of Injurious Wildlife under the Lacey Act; and 2) the potential for goldfish to be identified as crucian (*Carassius carassius*) or Prussian carp (*Carassius gibelio*), that already are on the USFWS list of Injurious Wildlife. The first step in the analysis was to identify which species were actively farmed and in trade at the time of the 2018 Census of Aquaculture (USDA-NASS 2019).

Table 6 lists the species on the petition for adding new species to the list of injurious species that will be the focus of this economic analysis and the sector of U.S. aquaculture that would be affected. Included are: blue catfish (*Ictalurus furcatus*), tilapia (*Oreochromis* spp.), grass carp (*Ctenopharyngodon idella*), koi carp (*Cyprinus carpio*), red swamp crawfish (*Procambarus clarkii*), and the guppy (*Poecilia reticulata*). Goldfish (*Carassius auratus*) was included to assess the impact from Scenario #2, in which goldfish would be identified as crucian or Prussian carp (Table 1). For each of these species, 2018 data were obtained from the Census of Aquaculture (USDA-NASS 2019) on: 1) the number of states where sales of each species were reported; 2) the number of farms reporting sales of each species; 3) the total volume of production reported for each species; and 4) the total sales reported for each species.

Spreadsheet models were developed for each of the seven species identified in Table 6 that were also reported to be in trade in the 2018 Census of Aquaculture (USDA-NASS 2019). Each spreadsheet model included the current farmed status of each (number of states where farmed, number of farms, total volume produced (by weight), and total sales). Based on the production and marketing characteristics of each species, an assessment was made of how many states and farms would likely be affected and an estimate of the losses based on the proportion of states/volume of production affected. Multipliers for economic output and employment from the relevant literature on the economic contributions and impacts of various aquaculture farming production/marketing structures were used to estimate the economic impact on output and employment of each of these species. For those sectors that primarily sell foodfish to processing plants, the multipliers used were those from Hegde (in review) and for sectors selling live fish or crustaceans, the multipliers from van Senten (2016) and van Senten (2017) were used. The magnitude of the economic impacts was compared across the seven species that would be affected.

Results

Results of the analysis will be discussed for each species in addition to a summation of the total effect for all seven species presented.

Blue catfish

Blue catfish are used in the U.S. catfish industry as the male parent of the blue catfish x channel catfish hybrid. By 2020, a survey of catfish producers revealed that 53% of the catfish production area was in production of the blue x channel hybrid (Hegde et al. in review). Thus, the injurious species listing of blue catfish would affect the economic contribution of those farms that either: 1) sell hybrid fingerlings across state lines or import hybrid fingerlings from another state; 2) buy or sell hybrid catfish foodfish into or from another state; or 3) buy blue catfish as broodstock from another state to raise hybrid catfish fingerlings or foodfish. The only state that sells its hybrids within the same state and has its own blue catfish broodstock is California; all other states are dependent upon interstate movement of either blue catfish or its hybrid.

In 2018, there were 28 states with a total of 531 farms growing and selling catfish (Table 7) (USDA-NASS 2019). The combined liveweight of catfish sold nationally in 2018 was 358.2 million pounds raised in 63,760 acres of water, for an average of 674,652 lb/farm. Total sales of catfish in the U.S. in 2018 were \$366.8 million (US). Catfish producers in 12 states reported selling hybrid catfish. Hybrid catfish farmers in all but one (California) of these 12 states rely upon interstate shipping for their farming businesses. Thus, 11 states (Alabama, Arizona, Arkansas, Florida, Georgia, Hawaii, Idaho, Illinois, Louisiana, Mississippi, and Texas) would be affected by listing the blue catfish as injurious under the Lacey Act. The specialized nature of the production of hybrid catfish has resulted in a low number of hatcheries that sell hybrid catfish fingerlings. Some hatcheries that produce hybrid catfish fingerlings purchase blue catfish broodstock from other states that transport broodstock across state lines to their hatchery. A number of catfish farms rely upon deliveries of hybrid catfish fingerlings from hatcheries in other states. Other farms sell hybrid catfish foodfish to processing plants in other states.

Listing the blue catfish as injurious under the Lacey Act would affect 11 states in the United States and approximately 97 farms with 27,090 acres of production. Lost production from these farms was estimated to be 166.6 million pounds with a total sales value of \$170.6 million dollars. The number of jobs lost on farms would be 665. Accounting for the indirect (supply chain actors such as supply companies, grain, transportation, utility, and other sectors from which catfish farms, mills, and plants purchase inputs) and induced effects (additional household spending) that would multiply the farm effect throughout the economy, would result in economic output losses of \$295.4 million and 1,419 jobs lost nationally.

If hybrid catfish were no longer available as a result of listing blue catfish under the Lacey Act, catfish farmers would likely be forced to return to raising only channel catfish. Such a change would result in dramatic decreases in production efficiencies that have been made possible by the use of hybrid catfish as a complementary input into the split-pond production systems (Hegde et al. in review). Profitability of catfish production with hybrid catfish in split-pond systems was found to be 2.87 times more economically feasible with superior cash flow than with the best-performing channel catfish production system (Kumar et al. 2020). Channel catfish have been found to not be suitable for production in split-pond systems. The adoption of the use of hybrid catfish in split ponds is the primary reason for the initiation of recovery of the U.S. catfish

industry following a period of major industry contraction because it offered improved efficiencies that have made it more competitive with the high volumes of imported pangasius catfish. Forcing the U.S. catfish industry to return to use of only channel catfish would have far greater negative effects than what was estimated above, with long-term industry profitability and competitiveness jeopardized.

Tilapia

Tilapia raised in the U.S. are primarily sold as live fish transported to major urban areas for sale in supermarkets that feature live tanks from which live fish are sold to consumers. Tilapia are raised in 27 states in the U.S. on 137 farms (Table 8) (USDA-NASS 2019). The estimated total weight produced of tilapia in 2018 was 14.7 million pounds, for an average weight of 107,445 pounds per farm. Total sales were \$39.4 million in 2018. Tilapia in some states are raised outdoors in flow-through or recirculating tanks, while tilapia raised in other states are raised primarily in indoor recirculating aquaculture systems (RAS). The values calculated accounted for the proportionately greater labor per volume of tilapia produced in RAS as compared to flow-through systems.

If interstate movement of tilapia were curtailed by listing the major tilapia species (*Oreochromis aureus*, *mossambicus*, and *niloticus*) as injurious under the Lacey Act, all states with tilapia farms would be affected, with the exception of California and Hawaii. Tilapia farms in California and Hawaii sell their fish within their respective states and either raise their own fingerlings or purchase them from in-state hatcheries. Tilapia farmers in 25 other states either purchase fingerlings from major hatcheries in southern-tier states or sell the majority of their tilapia to customers in other states.

The direct losses from prohibiting movement of live tilapia across state lines would be the loss of 10.1 million pounds of fish worth total sales of \$26.9 million and a loss of 305 on-farm jobs. When accounting for the total economic impact, the loss in economic output nationally would be \$81.6 million and 865 jobs would be lost nationally.

Not included in the analysis is that the loss of the availability of tilapia fingerlings that are purchased from the few commercial hatcheries in southern tier states, would cause further harm to high school programs that use tilapia production indoors as a way to integrate mathematics, biology, chemistry, and business disciplines, aquaponics hobbyists, and backyard enthusiasts for tilapia. Thus, prohibiting the interstate movement of live tilapia would cause harm to a variety of K-12 educational programs and to those who raise tilapia in recirculating aquaculture systems indoors, in greenhouses, or in aquaponics, for home consumption or as a hobby.

Grass carp

Grass carp are sold in the U.S. primarily as live fish for stocking into waterways, reservoirs, lakes, and private farm ponds for control of aquatic vegetation. Eighty-eight farms in 24 states reported sales of live grass carp in 2018 (Table 9) (USDA-NASS 2019). Total sales reported were \$7.72 million from 1.9 million pounds of grass carp sold. Total employment on these farms was estimated to be 509 jobs.

If grass carp were to be listed as injurious under the Lacey Act and prohibited from movement across state lines, all states that raise and sell grass carp would be affected. The majority of states require that grass carp sold into their state be certified by USFWS to be triploid fish. Only a few hatcheries in the U.S. produce triploid grass carp and these hatcheries ship grass carp live for resale by other fish farms in other states or directly to state agencies and other customers. Thus, all 24 states that list sales of grass carp would be affected if prohibited from moving fish to other states.

Lost economic output from prohibition of movement of grass carp to other states was estimated to be \$23.4 million, accounting for direct, indirect, and induced effects (Table 9). Total jobs lost were estimated to be 1,443.

The estimates of economic losses from prohibition of movement of grass carp across state lines does not account for the substantial benefit to inland waterway transportation, boating, and management as well as management of the hundreds of thousands of private farm ponds, fishing lakes, public lakes, and reservoirs used for boating, fishing, and other recreation. Grass carp are used for control of aquatic vegetation in lieu of herbicides that have, in the past, caused serious environmental harm.

Koi carp (common carp)

Koi carp are sold primarily as ornamental fish and pets for water gardeners across the U.S. In 2018, 149 farms in 29 states reported sales of koi carp (Table 10) (USDA-NASS 2019). Total sales reported in 2018 were \$8.1 million from an estimated 1.2 million pounds of koi carp. There were an estimated 178 jobs supported by koi carp farms across the U.S.

Koi carp are a variant of common carp known for their attractive bright coloration. If common carp were to be listed as injurious under the Lacey Act and prohibited from movement across state lines, all farms that raise and sell koi carp would be affected. Koi carp farms ship live fish across the U.S. to wholesalers and distributors as well as directly to retail customers, often through online sales.

Prohibition of interstate movement of live koi carp was estimated to result in lost economic output of \$24.7 million. The number of jobs lost across the U.S. was estimated to be 505.

Crawfish

Crawfish are raised and sold in the U.S. for both food and for bait. For this analysis, it is unlikely that crawfish sold as bait would be sold outside the state where raised. Those sold for bait tend to be smaller, sub-market size for food and tend to be sold locally. Thus, this analysis focused on crawfish sold as food.

In 2018, 482 farms in 11 states reported sales of crawfish for food (Table 11) (USDA-NASS 2019). Total sales were estimated to be \$50.8 million from a total volume sold of 44.3 million pounds. Total farm employment was estimated from Boucher and Gillespie (2015) at 336 jobs.

Crawfish farming is concentrated in Louisiana where an estimated 92.5% of all crawfish are produced in the U.S (McClain et al. 2005). According to Alexander (2019), 98% of farmed

crawfish are consumed in Louisiana. Thus, approximately 9.35% (7.5% of the crop raised in states other than Louisiana plus 1.85% of the Louisiana crop that is sold out-of-state) of the U.S. farmed crawfish crop would be affected by listing the red swamp crawfish as injurious under the Lacey Act.

Lost economic output from listing red swamp crawfish as injurious under the Lacey Act was estimated to be \$4.5 million. Sixty-seven jobs were estimated to be lost annually across the U.S. if live crawfish were prohibited from moved across state lines.

The petition by the Center for Invasive Species Prevention to list additional species also lists several other crawfish species. Most of those listed are not farmed and sold as food. However, if listed as injurious, a crawfish that occurs naturally in a region that is harvested and loaded incidentally in a load of other fish, such as baitfish or sportfish, and transported across state lines would then potentially be in violation of the Lacey Act. This would affect potentially all of the baitfish and sportfish sold annually in the U.S., with a total sales value of \$39,350,000 for sportfish and \$32,778,000 for baitfish in 2018 (USDA-NASS 2018). The total economic output of these sectors of U.S. aquaculture are \$99.3 million for baitfish and \$119.2 million for sportfish that could be affected by such an action.

Goldfish

Goldfish are farmed and sold in the U.S. for sale as feeder fish¹ and as ornamentals. In 2018, there were 89 farms that raised goldfish across 20 states (Table 12) (USDA-NASS-2019). Total sales of goldfish were \$5.1 million and supported an estimated 125 jobs.

Goldfish are not listed or proposed for listing as injurious under the Lacey Act. However, some taxonomists consider Prussian and Crucian carp as subspecies together with goldfish, part of the “*Carassius auratus* complex” rather than being separate species. The Prussian carp (*Carassius gibelio*) is basically identical in appearance to goldfish (Kalous et al. 2012). Thus, the potential for misidentification of goldfish as Prussian carp is a concern. If this were to be the case, there could be serious negative economic impacts if goldfish were prohibited from movement across state lines as a consequence of its similarity in appearance with Prussian carp. The total loss in economic output was estimated to be \$15.5 million with an estimated 355 jobs lost.

Total Economic Impact from Listing Seven Farmed Species that are in Trade as Injurious Under the Lacey Act

Listing all seven species as injurious under the Lacey Act and prohibited from movement across state lines would have a substantial impact on the economic contributions of the farms that raise these seven species and the jobs sustained throughout the supply chains of these species (Table 13). Such impacts would occur in 39 states² across the U.S. The total loss of economic output was estimated to be \$445,108,099 with 4,653 jobs that would be lost across the U.S.

¹ “Feeder fish” are fish sold to aquarium hobbyists to feed to carnivorous aquarium fish.

² Alabama, Arizona, Arkansas, California, Colorado, Connecticut, Florida, Georgia, Hawaii, Idaho, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maryland, Michigan, Massachusetts, Minnesota, Mississippi, Missouri, Nebraska, New Jersey, New Mexico, New York, North Carolina, Ohio, Oklahoma, Oregon, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas, Virginia, Washington, West Virginia, Wisconsin.

Discussion

The estimated effect of listing these seven species that are in trade as Injurious Wildlife would affect 78% of the states in the U.S. and cause substantial economic harm to 19% of all aquaculture farms in the U.S. Given that the value of the economic losses and the thousands of jobs that would be lost, such a regulatory action would constitute a significant effect on a substantial number of small business entities, given that 85% of U.S. aquaculture farms are categorized as small businesses. Thus, the Small Business Regulatory Enforcement Fairness Act of 1996 (SBREFA) would require that Small Business Advocacy Review Panels be convened.

Conclusions

The impact to U.S. aquaculture and to the U.S. from listing these seven species as injurious under the Lacey Act would be substantial. Several of the largest sectors of U.S. aquaculture would be affected, including the catfish sector, the largest sectors overall and of finfish, tilapia, the 3rd largest foodfish sector, crawfish, the largest sector of crustaceans, and the baitfish and sportfish sectors overall. The total economic loss throughout the supply chain was estimated to be \$445.1 million with a loss of 4,653 jobs.

Objective 3: Provide a management recommendation to the states in the southern region based on the outcomes of Objectives 1 and 2

The wide range of potential policy/regulatory options that state agencies may employ provides considerable uncertainty as to the eventual effects on southern regional aquaculture. The project investigators, following completion of Objective 1 and Objective 2 developed a series of recommendations concerning use of risk-based methods to support decision making, stakeholder inclusion, cost-benefit analysis, cooperation with other states, and other aspects of science-based management that incorporates aquaculture within its framework (see also Hill et al. 2018).

Recommendations:

- Adoption of science-based risk assessment frameworks will aid in identifying species as hazards and provide a strong basis for categorizing species invasiveness risk.
- Existing tools and development of state/region-specific tools can be tailored to provide transparent, repeatable, and defensible decision-support framework while simultaneously giving needed flexibility in non-native species management.
- Use of products (e.g., tools, assessments, or lists; especially the ERSS) developed by other agencies and academics can be used for guidance and information; nevertheless, critical review of these products is needed to ensure quality/accuracy, applicability, and overall fitness for purpose.
- Training, experience, and expertise improve risk assessment; regulatory agencies lacking expertise can seek assistance from other agencies, academics, or stakeholders.
- Stakeholder inclusion can improve risk assessment and is nearly essential for effective risk management and communication.
- Risk analysis is most useful when completed for the appropriate spatial scale; risk of most aquatic species is regional, reducing the effectiveness of the common practice of national-level assessment.

- Regional state coalitions and state-federal partnerships could combine and leverage resources to meet the regional nature of risk of invasiveness of aquatic species.
- Harmonization of regulations may be desirable or convenient for enforcement or simplicity but best employed when warranted by science-based risk analysis.
- Risk management is an essential component of risk analysis and allows for formal consideration of the benefits of non-native species as well as opportunities for risk mitigation.
- Increased opportunities for training/workshops in risk analysis, peer-review of risk assessment products, repositories of completed risk screens and assessments, and published accounts of risk analysis efforts would improve the resources needed for decision making in non-native species regulation and other management. Intergovernmental agencies/groups and professional societies could facilitate these activities.

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Impacts

- Opportunity to provide a broad range of policy recommendations to states regarding non-native species regulation and other management
- Actionable information relevant to assisting state agencies with information on risk-based tools and processes, procedures for listing prohibited and restricted/conditional species
- First economic evaluation of threat to southern regional aquaculture due to use and extension of authority of Lacey Act, Title 18, Injurious wildlife provisions
- Engagement with 47 of 50 state aquatic nuisance species coordinators; these staff are more aware of the issues and concerns of aquaculture industries; short shelf life
- Current list of regulated species by state; short shelf life
- Information on the extent that the ERSS and its outputs are used by state agencies in support of regulatory listing
- Opportunity to promote inclusion of stakeholders in the risk analysis processes

Publications, Manuscripts or Papers Presented

1. Publications

Peer-Reviewed:

None to date; two journal articles are planned, one covering the survey of state agencies (survey results, implications for southern regional aquaculture, and policy recommendations) and another covering the economic impacts on southern regional aquaculture of further injurious wildlife listing under a pending petition. A peer-reviewed extension publication (Florida Cooperative Extension Service – EDIS information system) is planned concerning risk assessment tools used by state agencies and our recommendations. A peer-reviewed USDA-SRAC extension fact sheet proposal will be offered to detail the project findings for a regional extension audience.

Theses & Dissertations:

None to date; A UF non-thesis, MFAS student will use select data from the survey results as the basis for his required technical paper.

2. Presentations:

a. Oral

None to date; Project staff will present the results of the study at conferences such as the American Fisheries Society Annual Meeting, Association of Fish and Wildlife Agencies, World Aquaculture Society/Aquaculture America, and other professional and trade conferences. Project staff will further provide this information to the Aquatic Nuisance Species Task Force and their regional panels (via presentation or publication formats). Project staff also are preparing a Webinar to provide this information to state agencies and industry groups.

b. Posters

None to date

Results at a Glance

Survey of aquatic nuisance species coordinators (47 of 50 states responded)

- Following Lacey Act ruling: 43 states made no changes, 3 added species to their prohibited list, and 1 state harmonized regulations with USFWS injurious wildlife lists
- Of the 43 states yet to make changes, 33 had no plan for changes, 9 were in the process of assessing their options, and 1 had plans for harmonization with USFWS lists
- 32 states had no standardized procedure for evaluating invasiveness risk of aquaculture species, 13 had a standardized process, and 2 used common processes but were not standardized
- 31 states had no intention of changing process and 16 were interested in changing or adopting a process
- 10 states used the USFWS ERSS (mainly outputs rather than new assessments), 5 indicated used of FISK or AS-ISK, 5 used an unknown/in-house process; other tools were used by single states
- Most states engaged in risk management activities in addition to risk assessment, but seldom used formal or structured processes
- Most states lacked in-house expertise in risk analysis, with some exceptions in the Midwest, west coast, and Florida
- The extent to which stakeholders were included in risk analysis efforts varied but was unclear and not standardized across states

Policy approaches

- Most policy options focused on possession, with prohibition on a case-by-case basis and harmonization with surrounding states the most common and balanced options; state laws universally prohibited release of non-native species without a permit; education and outreach were large components of non-native species policy in nearly all states
- Policy most likely to provide a balance between environmental protection and reasonable economic activity relative to southern regional aquaculture included prohibitions on a case-by-case basis using risk-based approaches, coordination with neighboring states, and harmonization with neighboring states if warranted

- Policy most likely to negatively affect southern regional aquaculture includes decision-making without support from risk-based approaches, blanket prohibitions, automatic harmonization with neighboring states, and automatic harmonization with USFWS Injurious Wildlife list

Potential economic impacts on southern regional aquaculture

- Pending petition of the USFWS to list new species as injurious threatens southern regional aquaculture, especially if the USFWS is granted the authority to prohibit interstate ships of injurious wildlife
- Several species could be impacted but the main southern regional aquaculture species affected would be blue catfish, tilapia (*Oreochromis* spp.), grass carp, koi carp, red swamp crawfish, and guppy, resulting in economic losses of at least \$429,558,935 and loss of 4,298 jobs
- Goldfish, though not listed currently and not petitioned for listing, may have genes of currently listed species (Crucian carp, Prussian carp). Enforcement could result in losses of \$15,549,164 and loss of 355 jobs

Table 1. Survey questions used to address Objective 1: “Explore the range of options available to evaluate the risks associated with permitting the transport of non-native species across state lines within the contiguous United States and how each state currently regulates these species”. The survey was designed to be conducted over the phone and take approximately 20-30 minutes.

#	Question
1	Which state agency or agencies have regulatory authority over the possession, production, transportation, and sale of non-native aquatic species (non-plant)?
2	What state regulations govern the possession, production, transportation, and sale of non-native aquatic species?
3	Does your state maintain a list of prohibited, conditional, etc. and/or permitted non-native aquatic species?
3b	Are there categories on the list (e.g., prohibited, possess with permit, etc.)?
3c	How are these resources accessed?
4	Does your state utilize a standardized procedure for evaluating risk?
4b	Does your state have plans to modify these approaches in the near future?
4c	Does your state utilize risk screens or assessments?
4d	If so, what are they?
5	Are stakeholders involved with risk assessment and/or management?
6	Does your state employ a formal risk management process?
6b	If so, what are they?
7	What state or regional groups does your state collaborate with to manage non-native aquatic species?
8	Does your state have aquatic invasive species specialists (employed or external) that aid in evaluating and managing risks?
9	What is the overall decision-making process?
10	Given the recent clarification of federal authority under the Lacey Act, what changes have been made in your state?
10b	Does your state have plans to respond or respond further to these changes?
10c	Do you have plans to harmonize state lists with the Injurious Wildlife list?
11	Anything else you might want to add?

Table 2. State responses to recent changes to the Lacey Act. While no states indicated that they would operate independently of the USFWS by not relying on Lacey Act for regulation and enforcement, several states identify this as a current approach.

Policy/regulatory responses	Response identified during survey?	Number of states identifying response	Strengths	Weaknesses
<i>No change</i>	Yes	43	No additional state resources required	If state regulatory gaps exist, greater potential for environmental costs
<i>Prohibit select Injurious Wildlife species</i>	Yes	3	Right sized approach based on risks associated with a particular species	May require additional state resources; Specialists may be required to determine which species to list based upon risk
<i>Harmonize state prohibited list with Injurious Wildlife list</i>	Yes	1	No additional state resources devoted	Could lead to unwarranted prohibitions of species that pose a low risk of invasion
<i>Operate independent of USFWS and listings under the Lacey Act</i>	No	0	More responsive to changes in risk; potential for development of regional consortiums	Costs associated with implementation of effective enforcement

Table 3. Policy and regulatory options (alongside strengths and weaknesses) identified during the survey and that may be possible.

Policy/regulatory options	Identified during survey	Strengths	Weaknesses
<i>Focused on possession</i>			
<i>No prohibited species</i>	Yes	Removes regulatory burden to industry; fewest state resources (initially) to implement	Focused on release and not possession; requires increased emphasis on preventing escape and release (education and outreach)
<i>Prohibit possession on a case-by-case basis</i>	Yes	Responsive to state needs; can incorporate a variety of approaches (including those below)	More state resources required, including specialists; difficult to enforce
<i>Harmonize state prohibited lists with neighboring states</i>	Yes	Fewer state resources to implement (shared burden); recognizes shared borders and risks	State microclimates may differ from neighboring states; may not fully account for species dispersal and shared climate
<i>Harmonize state prohibited lists according to bioclimatic regions</i>	No	Recognizes that risk is based on bioclimatic factors	Risk is often mitigated at the state and federal level; more state resources required
<i>Harmonize state prohibited lists with Injurious Wildlife list</i>	Yes	Fewest state resources needed; no specialized staff required to analyze risk	Ignores state microclimates which may differ from dominant climates of the U.S.; cedes control of management
<i>Possession of non-native species by permit only</i>	No	Maximizes environmental protection	More state resources required; species that pose little risk still need a permit

<i>Develop a clean list</i>	No	Maximizes environmental protection	Most state resources to implement; limited information to make adequate decisions; greater emphasis on enforcement
<i>Prohibit non-native species</i>	No	Maximizes environmental protection	Increases potential for genetic pollution; lost economic activity; requires greater state resources to implement enforcement

Focused on transport

<i>Separate possession from transport</i>	Yes	Increased economic activity through ports of entry	Increases regulatory complexity
<i>Transport of non-native species by permit only</i>	No	Maximizes environmental protection	Increased burden placed on commercial activity; difficult to enforce
<i>Prohibit transport of non-native species</i>	No	Maximizes environmental protection	Lost economic activity; risks of individual species not recognized; increase in state resources for enforcement

Focused on release

<i>Regulation of non-native species release</i>	Yes	Can be implemented with other policy/regulatory options	Increase in state resources for enforcement; release/escape unlikely to be identified
<i>Implementation of outreach and education</i>	Yes	Can be implemented with other policy/regulatory options	Relies on public and industry to do the right thing; increase in state resources for enforcement

Table 4. Risk screening and assessment tools available to state agencies and their characteristics.

Components	US Fish and Wildlife Service Ecological Risk Screening Summaries (ERSS)	Fish Injurious Species Risk Assessment Model (FISRAM)	Fish Invasiveness Screening Kit (FISK)	Aquatic Species Invasiveness Screening Kit (AS-ISK)	Generic Nonindigenous Aquatic Organisms Risk Analysis Review Process (Generic Analysis)
<i>Background</i>					
Risk approach (screen, assessment, management, communication)	Risk screening	Risk assessment (secondary assessment)	Risk screening	Risk screening	Risk assessment (usually comprehensive assessment)
Methodological approach	Climate matching and history of invasion and impacts; decision matrix	Probabilistic Bayesian	Semi-quantitative; question based	Semi-quantitative; question based	Qualitative; Seven risk elements
Uses expert opinion?	Limited; designed to be used with minimal training	Yes; estimates of node probabilities	Yes; select questions	Yes; select questions	Yes
Taxonomic coverage	Aquatic; fish, crustaceans, mollusks, plants, vertebrates, and invertebrates	Fish	Freshwater fish	Aquatic species	Any species or pathway

Coverage of hybrids and aquaculture varieties	Yes	Yes	Yes	Yes	Yes
Scalable to risk assessment area (growing region)?	No; USA	No (?); USA	Yes	Yes	Yes
Climate change considered	Not explicitly; can be used with different climate-matching scenarios	No	Not explicitly; can be used with different climate-matching scenarios	Yes	Not explicitly; can be used with different climate-matching scenarios
Stakeholder involvement	No	No	No	No	Common
<i>Information inputs</i>					
Transport	No	Yes; Human and non-human	Yes; Domestication and cultivation	Yes; Domestication and cultivation	Yes
Introduction	No	Yes; Human and non-human	Yes; Domestication and cultivation	Yes; Domestication and cultivation	Yes
Establishment	Yes; climate match and invasion history	Yes; Climate match	Yes; Climate match, invasion history; species/community traits	Yes; Climate match, invasion history; species/community traits	Yes
Spread	Yes; Climate match and invasion history	Yes; Climate match	Yes; Climate match, invasion history;	Yes; Climate match, invasion history;	Yes

			species/community traits	species/community traits	
Ecological impact	Yes; prior invasion impacts	Yes	Yes	Yes	Yes
Socioeconomic impact	Yes; prior invasion impacts	No	Yes	Yes	Yes
Socioeconomic benefit	No	No	No	No	No ^a
Potential for control	No	No	Yes	Yes	Not explicit; usually considered
<i>Outputs</i>					
Type of risk score	Qualitative	Quantitative	Semi-quantitative	Semi-quantitative	Qualitative
Risk category	Low, Uncertain, and High	Injuriousness; Yes, No, and Evaluate further	Low, Medium, and High	Low, Medium, and High	Low, Medium, and High; Overall risk potential
Calibration?	No	Preliminary; Set of known injurious and	Yes; Using receiver operating curve	Yes; Using receiver operating curve	No

		presumed non-injurious			
Assessment of uncertainty?	Yes; Overall screen; Categorical based on invasion history	Possible; Input variables can be toggled	Yes; For individual questions and overall screen; Also using multiple assessors	Yes; For individual questions and overall screen; Also using multiple assessors	Yes, for individual elements; Very certain, Reasonably certain, Moderately certain, Reasonably uncertain, and Very uncertain
Management/regulatory recommendations?	Yes; Part of process to list as Injurious	Yes; Part of process to list as Injurious	No ^b	No ^b	Yes, risk mitigation for Medium and High risk levels
Benefits versus risks	No	No	No	No	Yes, in risk management portion
Reference	USFWS 2016, 2020; Marcot et al. 2019	Marcot et al. 2019	Copp et al. 2009; Lawson et al. 2013	Copp et al. 2016	ANSTF 1996

Table 4 (con't).

Components	Regulatory system for non-native species (New York)	NOAA GLANSIS Watchlist	University of Notre Dame Science-Based Tools for Assessing Invasion Risk (STAIR)	National Detailed-Level Risk Assessment Guidelines: Assessing the Biological Risk of Aquatic Invasive Species in Canada
<i>Background</i>				
Risk approach (screen, assessment, management, communication)	Risk assessment; Risk management	Risk assessment	Risk assessment	Risk assessment
Methodological approach	Regulatory approach; Semi-quantitative questionnaire	Semi-quantitative; Question based	Classification tree	Semi-quantitative; Likelihood
Uses expert opinion?	Yes	Yes	No (Yes in model development)	Yes
Taxa coverage	Animals and plants	Aquatic species	Crayfish, Mollusks, Fish, Plants	Aquatic species

Coverage of hybrids and aquaculture varieties	No	Yes	Yes	Yes
Scalable to risk assessment area (growing region)?	Yes	No; Great Lakes	No; Great Lakes	Possible; Within Canada
Climate change considered	No; Assessors are instructed to keep climate change in mind	Yes	No	Possible
Stakeholder involvement	Possible	No	No	No
<i>Information inputs</i>				
Transport	No	Yes; Potential for introduction	No	Yes
Introduction	Yes	Yes; Potential for introduction	No	Yes
Establishment	Yes	Yes; Potential for establishment	Yes; Climate match	Yes
Spread	Yes	Yes; Potential for establishment	No	Yes
Ecological impact	Yes	Yes; Potential for impact	Yes	Yes

Socioeconomic impact	Yes; Human health, Economic, Cultural	Yes; Potential for impact	Yes	No; Part of risk management component
Socioeconomic benefit	Yes; Human health, Economic, Cultural	Yes; Potential for impact	No	No
Potential for control	Yes	Yes; Potential for establishment	No	No
<i>Outputs</i>				
Type of risk score	Semi-quantitative	Qualitative	Categorical	Qualitative
Risk category	Insignificant, Low, Moderate, High, Very High	Low; Moderate; high; Unknown for five categories	Fail/establish; Low and high impact	Low; Moderate; High
Calibration?	No	No	Yes; From expert assessment of successful invasives	No
Assessment of uncertainty?	Yes; Using multiple assessments	Yes; For questions and overall assessment	No; However, probabilities for categories	Yes; For sections and overall

Management/regulatory recommendations?	Yes; Includes regulatory system	No	No	No
Benefits versus risks	Yes; Socio-economic ranking summary	Yes; Scores for both Benefits and impacts	No	No
Reference	https://www.dec.ny.gov/docs/lands_forests_pdf/invasive062910.pdf	https://www.glerl.noaa.gov/pubs/tech_reports/glerl-169/tm-169.pdf	Howeth et al. 2015	Mandrak et al. 2012

^aBenefits can be considered in the risk assessment portion of the Generic Analysis but is seldom done. Most agree that risk assessment is about risks, not benefits. Benefits enter during the management phase, and this is explicit in the Generic Analysis.

^bFISK previously and AS-ISK presently used within the European Union for regulatory purposes regarding new aquaculture species (European Non-native Species in Aquaculture Risk Analysis Scheme (ENSARS)).

Table 5. Implications of four policy/regulatory options on five criteria, economic activity, resource activity, enforcement feasibility, scale of regulation (i.e., related to climate suitability), and prevention of introduction. In terms of economic activity, the policy/regulatory options may be species specific; thus, they are largely variable.

Policy/regulatory options	Economic activity	Resources required	Enforcement feasibility	Appropriate scale of regulation	Prevention of introduction
<i>Prohibit possession on a case-by-case basis</i>	Variable	Increased	Increased	Increased	Increased
<i>Harmonize state prohibited lists with neighboring states</i>	Variable	Decreased	Increased	Increased	Increased
<i>Harmonize state prohibited lists according to bioclimatic regions</i>	Variable	Increased	Increased	Increased	Increased
<i>Harmonize state prohibited list with Injurious Wildlife list</i>	Decreased	Decreased	Increased	Decreased	Increased

Table 6. Species on the petition to add new species to the List of Injurious Species under the Lacey Act that are farmed and in trade.

Species	Scientific name	Sector of U.S. aquaculture affected
Blue catfish	<i>Ictalurus furcatus</i>	Catfish
Tilapia		
Blue tilapia	<i>Oreochromis aureus</i>	Tilapia
Mozambique tilapia	<i>Oreochromis mossambicus</i>	Tilapia
Nile tilapia	<i>Oreochromis niloticus</i>	Tilapia
Grass carp	<i>Ctenopharyngodon idella</i>	Aquatic vegetation control, states, inland waterways
Common carp	<i>Cyprinus carpio</i>	Koi carp/tropical, ornamental, pet trade
Red swamp crayfish	<i>Procambarus clarkii</i>	Crawfish
Guppy	<i>Poecilia reticulata</i>	Tropical, ornamental, pet trade
Goldfish ^a	<i>Carassius auratus</i>	Tropical, ornamental, pet trade

^aIf identified as crucian or Prussian carp already listed as injurious.

Table 7. Effect^a of listing blue catfish, *Ictalurus furcatus*, as injurious under the Lacey Act.

Category	Current status of U.S. catfish farming^a	Hybrid catfish^a	If movement across state lines was prohibited^b
Number of states	28	12	11 ^c
Number of farms	531	121	97
Total weight (lb)	358,240,000	207,779,200	166,566,797
Average per farm	674,652	1,717,183	1,717,183
Total sales (\$)	\$366,843,000	\$212,768,940	\$170,566,836
Total acres	63,760	33,793	27,090
Total sales per farm acre	5,753	6,296	6,296
Total economic output, from farms, hatch., feed mills, processors	568,185,787	329,547,757	264,182,912
Employment, direct	4,524	830	665
Economic impact			What is lost
Output (\$)	\$984,012,288	\$368,483,789	- \$295,396,095
Employment (number of jobs)	9,648	1,770	- 1,419

^aUSDA-NASS (2019).

^bOf blue catfish broodstock or of hybrid catfish fry, fingerlings, stockers, or foodfish.

^cStates other than California that has blue catfish broodstock and sells all hybrid catfish instate.

Table 8. Effect of listing tilapia as injurious under the Lacey Act.

Category	Current status ^a	If movement across state lines was prohibited
Number of states	27	25 ^b
Number of farms	137	116
Total weight (2018)	14,720,000	10,060,940
Total weight per farm	107,445	86,732
Total sales (\$)	39,395,000	26,926,000
Total acres	n.a. ^c	n.a.
Employment	n.a.	305 ^d
Economic impact		What is lost
Output (\$)	119,377,454	- \$81,593,028
Employment (number of jobs)	1,053	- 865

^aUSDA-NASS (2019).

^bWould affect all but CA and Hawaii, that have in-state hatcheries and sell primarily in-state.

^cn.a. = not applicable.

^dEmployment values accounted for greater employment per volume of tilapia sold in RAS as compared to flow-through systems.

Table 9. Effect of listing of grass carp as injurious under the Lacey Act.

	Current status ^a	If movement across state lines was prohibited
Number of states	24	24 ^b
Number of farms	88	88
Total weight (2018)	1,892,000	1,892,000
Total weight per farm	21,500	21,500
Total sales (\$)	7,715,000	\$ 7,715,000
Total acres	3,784	3,784
Employment	509	509
Economic impact		What is lost
Output (\$)	\$23,378,527	- \$23,378,527
Employment (number of jobs)	1,443	- 1,443

^aUSDA-NASS (2019).

^bAll states would be affected movement across state lines was prohibited.

Table 10. Effect of listing of koi carp (common carp) as injurious under the Lacey Act.

	Current status^a	If movement across state lines was prohibited
Number of states	29	29 ^b
Number of farms	149	149
Total weight (2018)	1,181,567	1,181,567
Total weight per farm	7,930	7,930
Total sales (\$)	8,141,000	8,141,000
Average price	6.89	7
Total acres	1,182	1,182
Employment	178	178
Economic impact		What is lost
Output (\$)	\$24,669,421	- \$24,669,421
Employment (number of jobs)	505	- 505

^aUSDA-NASS (2019).

^bAll states would be affected movement across state lines was prohibited.

Table 11. Effect of listing of red swamp crawfish as injurious under the Lacey Act.

	Current status^a	If movement across state lines was prohibited
Number of states	11	11
Number of farms	482	45
Total weight (2018)	44,332,000	4,145,042 ^b
Total weight per farm	91,975	91,975
Total sales (\$)	\$50,848,000	\$4,754,288 ^b
Total acres	94,880	8,871
Employment	336	31
Economic impact		What is lost
Output (\$)	\$48,362,182	- \$4,521,864
Employment (number of jobs)	716	-67

^aUSDA-NASS (2019).

^b92.5% of all crawfish production is in LA (McClain et al. 2005 + 2% of LA production goes out of state (2% of 92.5% is 1.85%; 7.5% + 1.85% is 9.35% of crawfish production would be affected).

Table 12. Effect of listing of goldfish as injurious under the Lacey Act.

	Current status^a	If movement across state lines was prohibited
Number of states	20	20 ^b
Number of farms	89	89
Total weight (2018)	n.a.	n.a.
Total weight per farm	n.a.	n.a.
Total sales (\$)	\$5,131,282	\$5,131,282
Total acres	n.a.	n.a.
Employment	125	125
Economic impact		What is lost
Output (\$)	\$15,549,164	- \$15,549,164
Employment (number of jobs)	355	- 355

^aUSDA-NASS (2019).

^bAll states would be affected movement across state lines was prohibited.

Table 13. Total estimated economic impact of listing seven species of farmed aquatic animals in trade in the U.S. as injurious under the Lacey Act that would lead to an effective prohibition of their movement across state lines.

	Farms affected (number)	Value of lost economic output	Number of jobs lost
Blue catfish	97	\$295,396,095	1,419
Tilapia	116	\$81,593,028	865
Grass carp	88	\$23,378,527	1,443
Koi carp (common carp)	149	\$24,669,421	505
Red swamp crawfish	31	\$4,521,864	67
Guppy			
Goldfish	89	\$15,549,164	355
TOTAL	570	\$445,108,099	4,653

Informed Consent for USDA Southern Regional Aquaculture Center Phone Survey

Hello. I am (Name) (Job Title) from the University of Florida/IFAS Tropical Aquaculture Laboratory. I am calling to ask a series of questions related to non-native aquatic species regulation and management in your state. You have been chosen based on publicly available information on state aquatic nuisance species coordinators and other state invasive species contacts.

The title of the study is “Policy analysis of the implications of changes in federal authority under the Lacey Act to prohibit interstate movement of injurious wildlife.” It is funded by the U.S. Department of Agriculture—Southern Regional Aquaculture Center. The goal of the study is to determine how states have and are responding to recent regulatory changes to the Lacey Act. This information will be used to determine policy and economic implications for live, interstate trade in southern regional aquaculture commodities.

I will read to you an informed consent statement.

This survey is completely voluntary on your part and you may opt out at any time. You may decline to answer any individual question. This survey should take no more than 20-30 minutes. There is no direct benefit for you for participation and there is no penalty for you for participation or non-participation. Your answers will be coded with no unique identifiers (e.g., no personnel names and no phone number). All survey data will be maintained in confidentiality to the extent possible.

Do you have any questions for me before we proceed?

Please indicate by a ‘yes’ that you will voluntarily participate in the survey or by a ‘no’ that you will not voluntarily participate.

Figure 1. Informed consent statement read by project staff prior to conducting the survey of aquatic nuisance species coordinators. The informed consent statement was designed to inform the coordinators of the identify of project staff, purpose of the survey, the funding source, and how the data will be treated.

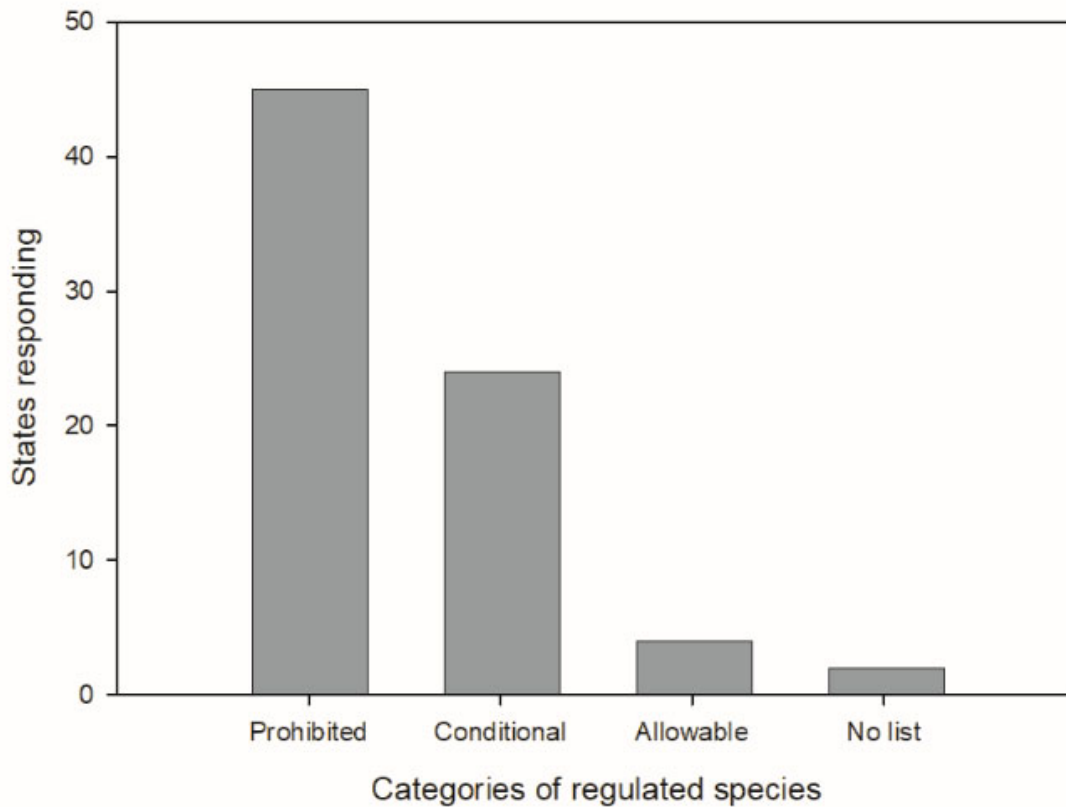


Figure 2. Regulatory categories for the possession of non-native, non-plant aquatic species. Categories Answers were in response to questions 3 and 3b in table 1. Approximately half of all responding states utilized a prohibited category (possession is not allowed) and a conditional category, where conditions had to be met, often the acquisition of a permit or adequate containment. A small number of states (4 states) utilized an allowed species list, also known as a white or clean list, but in each instance the state also had a prohibited species list.

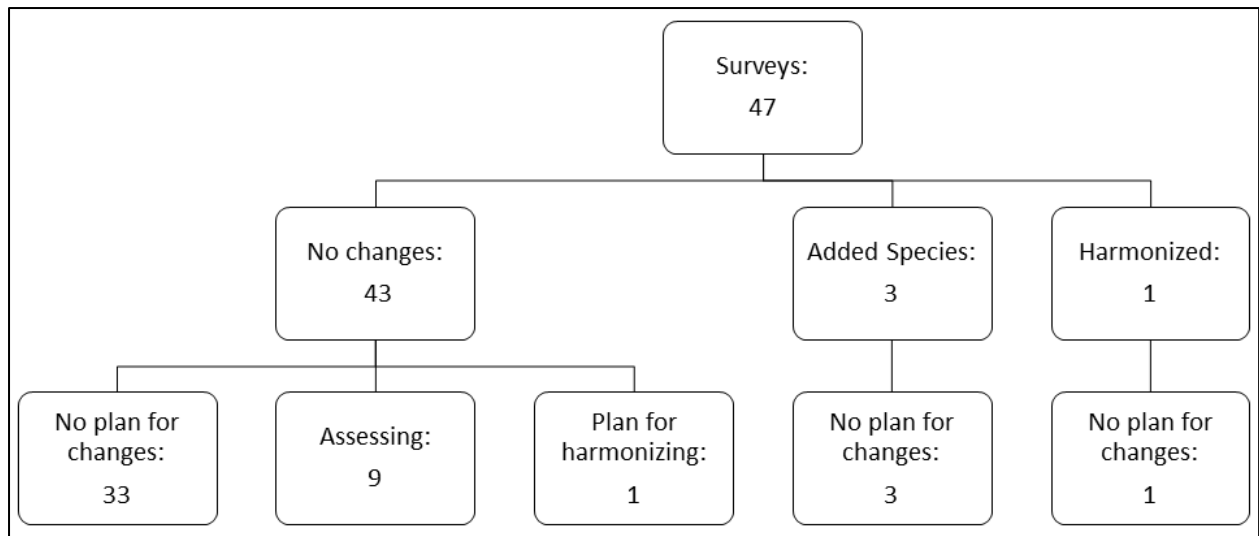


Figure 3. Responses from surveys of aquatic nuisance species coordinators on changes following the Lacey Act ruling. Most state coordinators indicated that no changes were made and there are no plans for changes. Fewer coordinators indicated that their state is assessing the implications of the changes to Lacey Act.

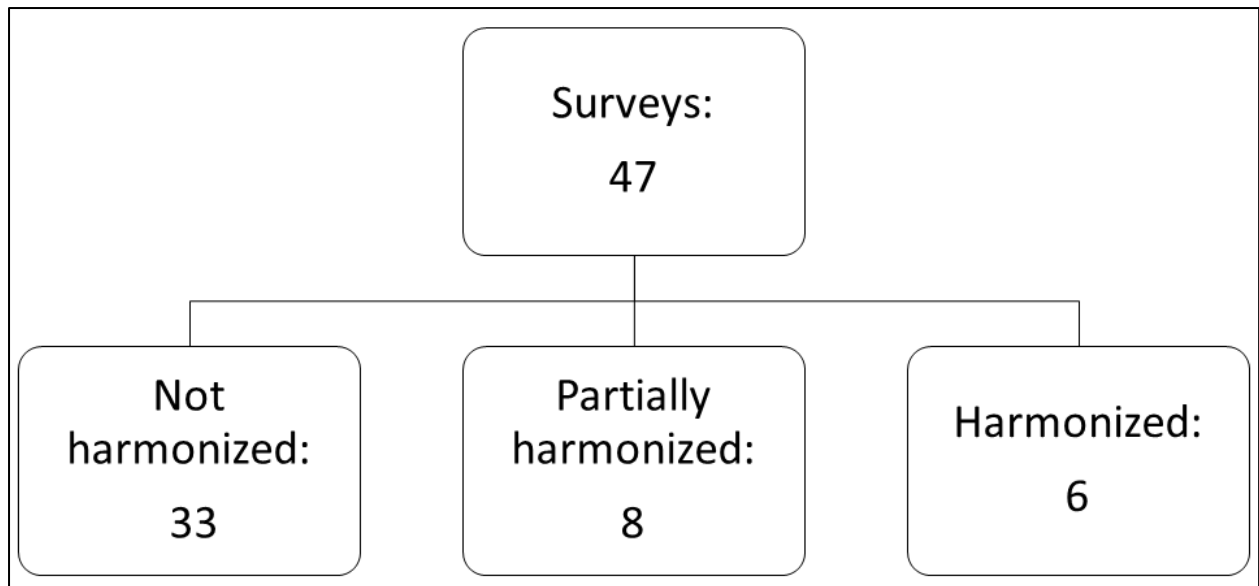


Figure 4. Responses from surveys of aquatic nuisance species coordinators on whether the state list of prohibited species has been harmonized with the Federal Injurious Wildlife list. Most state coordinators indicated that the state list has not been harmonized.

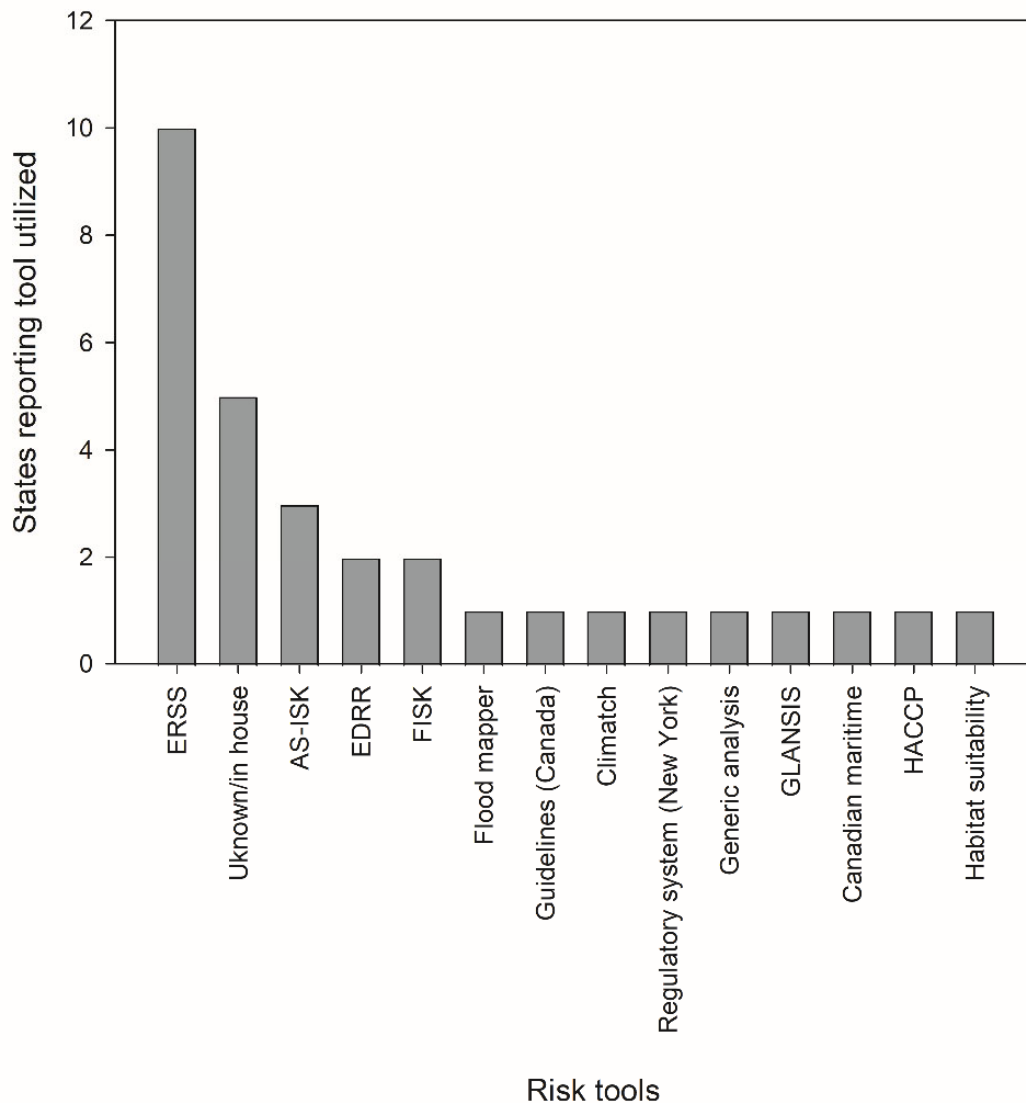


Figure 5. Risk tools reported during a survey of ANS coordinators. ERSS = Ecological Risk Screening Summaries; AS-ISK = Aquatic Species Invasiveness Screening Kit; EDRR = Early Detection Rapid Response; FISK = Fish Invasiveness Screening Kit; Flood mapper = Flood and Storm Tracker Maps; Guidelines (Canada) = National Detailed-Level Risk Assessment Guidelines: Assessing the Biological Risk of Aquatic Invasive Species in Canada; Regulatory system (New York) = Regulatory system for non-native species; Generic Analysis = Generic Nonindigenous Aquatic Organisms Risk Analysis Review Process; GLANSIS = National Oceanographic and Atmospheric Association, Great Lakes Aquatic Nonindigenous Species Information; Canadian maritime = Canadian maritime invasiveness screening tool; HACCP = Hazard Analysis Critical Control Point.

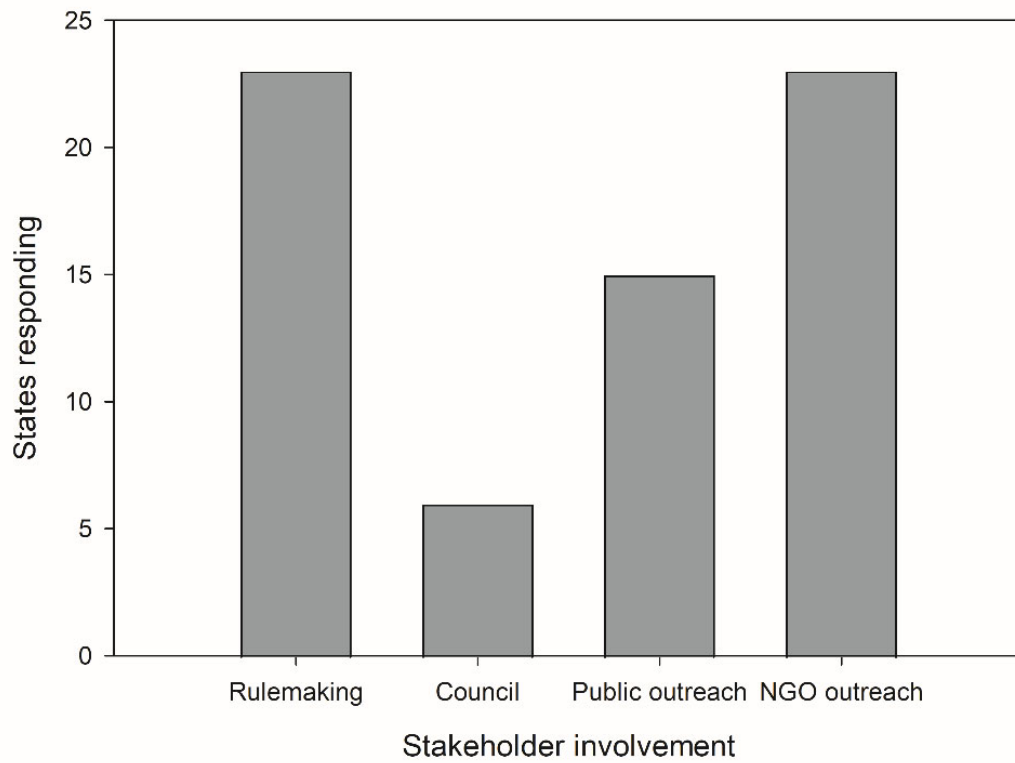


Figure 6. Number of states reporting that stakeholder involvement was utilized during the rulemaking process, through participation on an invasive species council, and through public and non-governmental agency outreach.

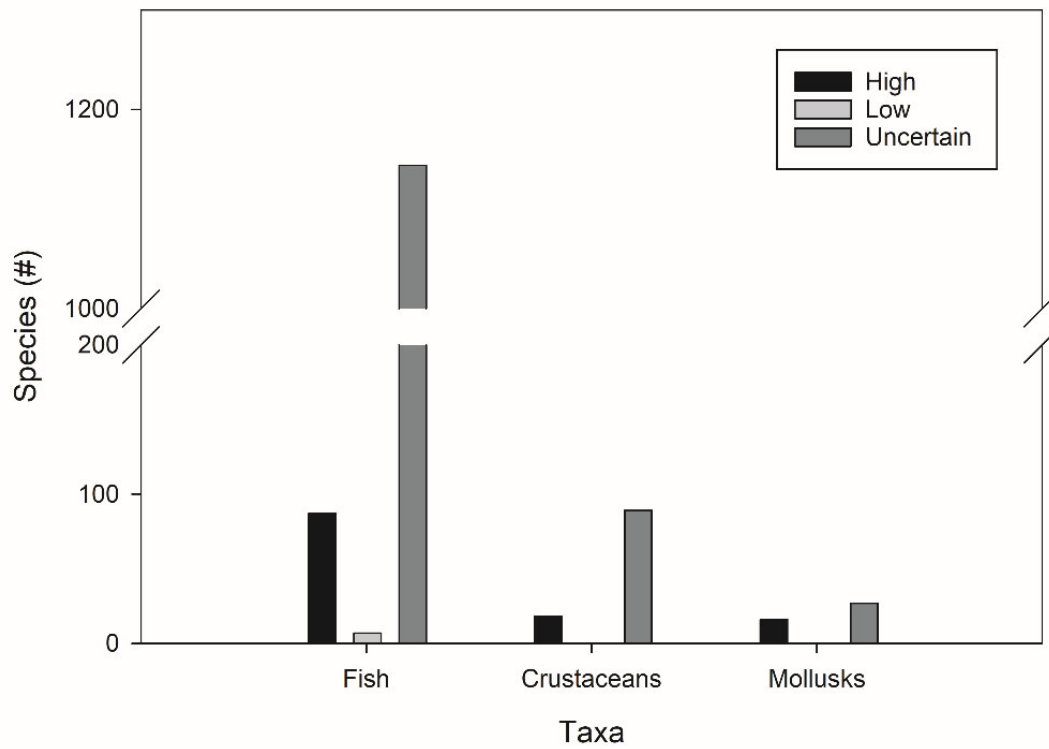


Figure 7. The number of species classified as High, Low, and Uncertain risk in the ERSS by Taxa, Fish, Crustaceans, and Mollusks. Most assessed species were determined to exhibit Uncertain risk, followed by High risk. Only seven Fish species were determined to exhibit Low risk; zero crustaceans and Mollusks were found to exhibit Low risk. Data were up to date as of 5-7-2021.