

Reducing Impacts of Exotic Crayfish Introductions:

New Policies Needed

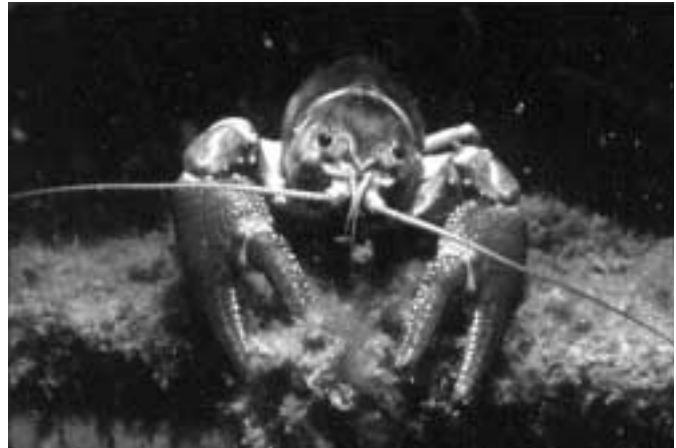
By David M. Lodge, Christopher A. Taylor, David M. Holdich, and Jostein Skurdal

In February 1999, President Clinton mandated the development of an Invasive Species Management Plan for the United States, emphasizing in Executive Order 13112 the severity of the economic, human health, and ecological threats posed by nonindigenous species (NIS). The plan must review the anthropogenic vectors that move species, and recommend measures to minimize future introductions. Elsewhere in this issue, we have reviewed the special threats to freshwater biodiversity and ecosystem function posed by nonindigenous crayfishes (from within North America and from other continents), and identified the vectors potentially most important in introducing crayfishes: aquaculture; aquarium and pond trade; biological supply trade; and the live bait trade. In this essay, we outline recommendations for reducing future crayfish introductions in the United States by these vectors, and call for the development of methods to eradicate or control nonindigenous crayfishes. We hope that these recommendations will be considered during the development of the Invasive Species Management Plan.

While we believe our recommendations may apply to many freshwater animal and plant taxa, we focus on crayfishes in this essay for the following reasons. First, the United States encompasses about 350 species of crayfishes, 70% of the world's total. Second, these crayfishes are among the most threatened of all terrestrial and aquatic species in the United States. Finally, although U.S. crayfishes are severely threatened, there remains a window of opportunity to implement policies that could prevent the extinction of many native crayfishes and prevent the large ecosystem changes that often accompany introductions of nonindigenous crayfishes. Our hope is to avoid the ecological and economic disasters that befell the fisheries for European crayfishes after the introduction of nonindigenous crayfishes there.

David M. Lodge is an aquatic ecologist and professor in the Department of Biological Sciences, University of Notre Dame, Notre Dame, IN 46556; lodge.1@nd.edu. Christopher A. Taylor is an associate research scientist with the Illinois Natural History Survey, Center for Biodiversity, 607 East Peabody Drive, Champaign, IL 61820; ctaylor@mail.inhs.uiuc.edu. David M. Holdich is reader in zoology in the School of Biological Sciences, University of Nottingham, Nottingham NG7 2RD, UK; david.holdich@nottingham.ac.uk. Jostein Skurdal is a senior scientist at the Norwegian Institute for Nature Research, Fakkelgården, N-2624 Lillehammer, Norway; jostein.skurdal@ninalil.ninaniku.no.

In Europe and North America, nonindigenous crayfishes have often eliminated native crayfishes from lakes and streams, eliminated aquatic vegetation where it is important fish and macroinvertebrate habitat, reduced abundance of insect larvae and other invertebrates used by fishes, and reduced abundance of native amphibians. Nonindigenous crayfishes have had additional devastating impacts on the commercial fishery for native European crayfishes, which have much greater market value than the introduced species. European harvests of crayfish for human consumption are now only about 5% of their historic levels; many European countries have implemented



D. Stamm, ProPhoto

The rusty crayfish (*Orconectes rusticus*) has significantly affected lake and stream ecosystems in the many areas of the United States and Canada where it has been introduced. This essay makes recommendations to control introductions of nonindigenous species.

severe restrictions on transport of live nonindigenous crayfishes, including bans on importation in Ireland and Norway (Gherardi and Holdich 1999). These ecological and economic impacts are detailed in our feature article (this issue). Most North American crayfishes occur in the southeastern United States, and have small natural ranges, making their continued existence highly vulnerable to NIS. These facts suggest strongly that the United States is in a good position to act now to prevent a repetition of the European experience.

Current federal and state regulations are inadequate to stem the tide of freshwater NIS (U.S. Congress 1993), including nonindigenous crayfishes (see accompanying feature, this issue). Therefore, we hope that new federal

actions will be consistent with our recommendations below. Regardless of federal action, we hope that states will incorporate these recommendations into their aquatic nuisance species management plans, the development of which were encouraged by the federal Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990.

Recommendations

To protect our native crayfish faunas, our fisheries, and our freshwater ecosystems from the impacts of NIS, we advance the following strategies. It is our hope that these ideas will initiate discussions and actions amongst policy makers, resource managers, the affected industries, other stakeholders, and the public at both the state and federal levels. We recognize some difficult dilemmas in balancing the needs for resource protection and the needs of affected industries. Nevertheless, we feel that the documented effects of introduced crayfishes warrant strong new steps to protect aquatic biodiversity and freshwater ecosystems. We make two general recommendations, followed by specific recommendations for each of four important vectors of introduction of nonindigenous crayfishes. We hope to enhance understanding of the issues and to stimulate dialog on appropriate responses.

Our first general recommendation is the adoption of a white list approach that would preclude moving any species between catchments within a state, between states, and from other continents until adequate screening of the characteristics of a given species has been conducted. A federal white list should govern proposed introductions of species from other continents. States should be required to appoint a lead agency to develop white lists to govern species movements between catchments within states and between states. Assessments for proposed white listing should include information on invasiveness in any other locations in which the species has been introduced, diseases, parasites, commensals, environmental tolerances, and life history characteristics. Results of assessments should be reviewed by independent scientists, perhaps coordinated by the American Fisheries Society (AFS). Because the risks of release to the natural environment differ among vectors, we foresee the possibility for different white lists for different vectors, as indicated below.

A second general recommendation is for research on methods to eradicate localized populations of crayfishes while minimizing impact on nontarget species (Gherardi and Holdich 1999), and on methods for maintenance control of more widespread non-indigenous crayfishes. Each state needs a lead agency with authority to respond quickly to eradicate newly established populations of nonindigenous crayfishes, and to manage those that cannot be eradicated.

Aquaculture. As aquaculturists begin to experiment with crayfishes from other locations within North America and from other continents (Semple et al. 1995), the potential for species introductions from this vector looms large. In Great Britain, aquaculture of the North American *Pascifastacus leniusculus* led to feral populations (some infected with crayfish plague) that led to the extirpation of many


populations of the native British species, *Austropotamobius pallipes*. In the United States, current state laws governing aquaculture range widely, from extensive permit applications under a white listing approach (Tennessee, Illinois), to no regulations (Arkansas). Even in many states where commercial aquaculture is regulated, it is legal for anyone to import and culture a nonnative species in a noncommercial enterprise. The white list approach in Illinois was recently instrumental in prohibiting the proposed introduction of the Australian crayfish *Cherax*. *Because crayfishes invariably escape from outdoor aquaculture facilities, we advocate that the most stringent possible criteria should govern white listing proposals for aquaculture.*

Aquarium and garden pond trade. Escapes from outdoor culture facilities, and intentional releases by aquarium hobbyists have been responsible for the establishment of many nonindigenous fishes in Florida and other locations. Although we are unaware of any documented crayfish introductions by this vector, we have seen multiple species of crayfishes for sale in aquarium and pond shops, and it is clear that great potential for releases exists. *These trades must be brought under a white list approach, and all sales must be accompanied by required educational materials and warnings to hobbyists about the dangers of releasing NIS species. Proposals for outdoor culture facilities should be scrutinized with the same criteria we advocate above for aquaculture facilities.*

Biological supply trade. Several species of crayfishes, including the known invasive species *Procambarus clarkii* and *Orconectes rusticus*, are currently sold live by many biological supply companies and legally shipped into many states. *In addition to bringing this trade under a white listing approach, educational materials and warnings to teachers and students about the dangers of releasing NIS should be required to accompany all shipments.*

Live bait trade. The live bait trade has resulted in the introductions of numerous nonindigenous fishes and other organisms, including crayfishes (Ludwig and Leitch 1996). We believe that release of live bait is the most important vector for introductions of nonindigenous crayfishes. Nevertheless, importation of bait across state lines is at best loosely regulated, with most states requiring nothing more than an easily obtained bait dealer's license (Meronek et al. 1995). Release of aquatic bait organisms is illegal in only a very few states (e.g., Kentucky, Georgia), and the laws apply only to species not native to the state (leaving inter-catchment introductions legal). Michigan and Illinois ban the possession of live *Orconectes rusticus*, but most biologists (let alone anglers) have difficulty distinguishing one crayfish species from another.

Beginning in 1983, Wisconsin banned the use of all live crayfishes as bait, and public comments were 5:1 in favor of the proposed ban (Tim Simonson, Wisconsin Department of Natural Resources, pers. comm.). Adoption of the ban caused no unusual controversy, and has not caused any apparent harm to Wisconsin's important fishing industry. The Wisconsin policy is one other states should implement, but before the problem becomes irreversible.

Regulations aimed at restricting *O. rusticus* in Wisconsin, Michigan, Illinois, and Minnesota were enacted only after *O. rusticus* had become a serious nuisance in all four states. Even in those states, *O. rusticus* has continued to spread into waters connected to those in which it had previously become established. Once established, no methods exist by which a nonindigenous crayfish can be exterminated without unacceptable harm to native crayfishes and other organisms. To be most effective, especially in southeastern states containing tens to hundreds of endemic crayfish species with small ranges, regulations should be implemented before NIS introductions occur, thus preventing native species extinctions and changes in energy flow to fishes. If states ban sales of live crayfishes or ban importation of live crayfishes, the problem would be only partly addressed. *To halt this avenue of nonindigenous crayfish introduction, we advocate making the use of live crayfishes as bait illegal in all states.* This and other steps need to be accompanied with strong public education programs like those initiated in Great Britain to explain the dangers of introducing crayfishes. 

References

- Gherardi, F., and D. M. Holdich, eds. 1999. Crayfish in Europe as alien species. How to make the best of a bad situation? A. A. Balkema, Rotterdam and Brookfield.
- Ludwig, H. R. Jr., and J. A. Leitch. 1996. Inter-basin transfer of aquatic biota via anglers' bait buckets. *Fisheries* 21(7):14-18.
- Meronek, T. G., F. A. Copes, and D. W. Coble. 1995. A summary of bait regulations in the north central United States. *Fisheries* 20(11):16-23.
- Semple, G. P., D. B. Rouse, and K. R. McLain. 1995. *Cherax destructor*, *C. tenuimanus* and *C. quadricarinatus* (Decapoda: Parastacidae): a comparative review of biological traits relating to aquaculture potential. *Freshw. Crayfish* 8:495-503.
- U.S. Congress. 1993. Harmful Non-Indigenous Species in the United States. Office of Technology Assessment, OTA-F-565. September 1993. U.S. Government Printing Office, Washington, DC.