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Relaxed Attitude Towards Spreading of Alien Crayfish Species Affects Protection of Native Crayfish Species: Case Studies and Lessons Learnt from a Fennoscandian Viewpoint

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ABSTRACT

The spreading of the alien signal crayfish (*Pacifastacus leniusculus*) is posing an ongoing threat to native European crayfish species in Fennoscandia, like the native noble crayfish (*Astacus astacus*). The signal crayfish is commonly a chronic carrier of the crayfish plague (*Aphanomyces astaci*), thus, in addition to being more competitive than noble crayfish, it also has a competitive advantage in this disease over the noble crayfish. The challenges rising from the introduction of the alien signal crayfish to Sweden, Finland and finally also Norway, are similar in nature. The licensed and unlicensed spreading of this species also has a similar history in these countries. In this paper we describe some of the patters of the spread of alien signal crayfish and highlight the detrimental nature of an alien crayfish, accompanied by a highly virulent disease, to native Fennoscandian crayfish and also to native Fennoscandian ecosystems. A halt to the further spreading of alien signal crayfish in Fennoscandia is the only means to ensure successful conservation outcomes for the noble crayfish.

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INTRODUCTION

The Fennoscandian countries share a common dynamic history (Derry 2000) which also includes a common cultural crayfish heritage and lively crayfish festivals which result in high values for the native crayfish catch (Ackefors 1998; Fürst and Törngren 2003; Jussila et al. 2015a). Traditionally, income from crayfish trapping has been used as a side income for both families and individuals (Jussila 1995; Jussila et al. 2015a). This economic value of the native crayfish has added to the nonmonetary recreational benefits enjoyed during the crayfish trapping season, which has led to various anecdotes included in the Fennoscandian folklore (e.g., Ackefors 2005; Jormanainen 2015). The introduction of the crayfish plague disease agent, *Aphanomyces astaci* (Schikora), in the late 19th century largely terminated the era of prosperous native crayfish trapping (Alderman 1996; Jussila and Mannonen 2004; Bohman and Edsman 2011). This created a situation where substitutes for the formerly productive noble crayfish stocks were studied in order to revitalize the crayfisheries in Sweden and Finland (Svärdson 1995; Westman 2000). Currently, only a fraction of the native Fennoscandian crayfish stocks are productive (Edsman 2004, Jussila and Mannonen 2004, Bohman and Edsman 2011) and the noble crayfish (*Astacus astacus* (Linnaeus)) has been facing a threatened conservation status throughout Europe (e.g., IUCN Red List (2017) and EU Red List). The conservation status of the noble crayfish was recently updated in Finland to endangered, EN A2a,b,c,e (Hyvärinen et al. 2019) and in Sweden it has been listed as critically endangered (CR) since 2010 (e.g., Bohman and Edsman 2011; ArtDatabanken 2015).

The decision to introduce a North American crayfish species as a substitute for the disappearing noble crayfish stocks was seen as the best solution in both Sweden and Finland, resulting in the alien signal crayfish (*Pacifastacus leniusculus* (Dana)) being the species of choice for the first introductions during the 1960's (Fjälling and Fürst 1985; Kirjavainen and Sipponen 2004; Ruokonen et al. 2018). Despite the warnings regarding possible adverse effects to the native aquatic ecosystem and remaining native noble

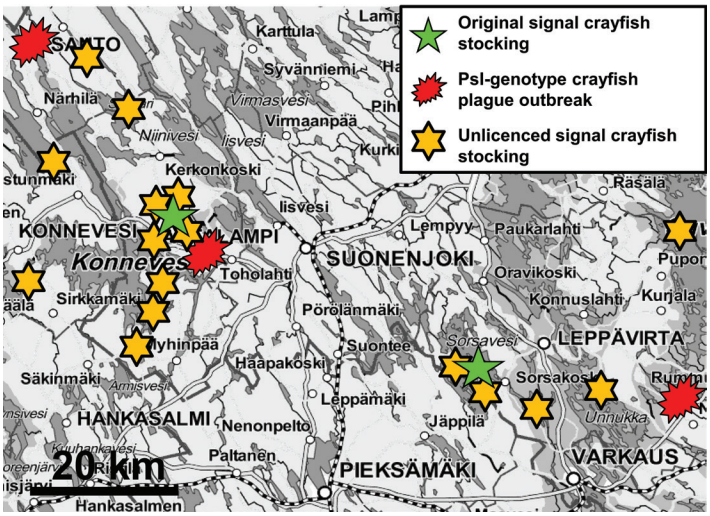

Figure 1. The relationship between licensed alien signal crayfish stockings, unlicensed alien signal crayfish stockings and PsI-genotype (B haplogroup) *Aphanomyces astaci* infection outbreaks in a noble crayfish stock in the Central Savo region of central Finland. Information collected from Northern Savo Center for Economic Development, Transport and the Environment database (licenced signal crayfish stockings), Natural Resources Institute Finland database (signal crayfish distribution) and Crayfish Innovation Center and Finnish Food Authority databases (crayfish plague epidemics).

crayfish stocks (e.g., Westman 1973; Unestam 1975), the first test introductions of the alien signal crayfish in the 1960s and 1970s gradually developed into massive introduction programs during 1980s and 1990s (Westman 2000; Bohman et al. 2006; Ruokonen et al. 2018). Right from the start, the experiences were conflicting, but the enthusiasm overcame attempts to consider the situation in more detail. Thus, the southern parts of both Sweden and Finland were quickly overtaken by the alien signal crayfish (Skurdal et al. 1999; Kirjavainen and Sipponen 2004; Bohman et al. 2006; Souty-Grosset et al. 2006; Edsman and Schröder 2009). This also meant dire times for the remaining noble crayfish in those parts of Fennoscandia, not least because of the crayfish plague epidemics (especially *A. astaci* from the PsI-genotype or B haplogroup) became more commonplace among the noble crayfish stocks (Jussila et al. 2015a, Jussila et al. 2015b).

Recently, there has been increasing concern regarding the future of the struggling noble crayfish stocks due to translocations of the alien crayfish (Furse 2008; Holdich et al. 2009; Manfrin et al. 2018; Ruokonen et al. 2018), substandard performance of the alien signal crayfish (Jussila et al. 2014a; Sandström et al. 2014; Edsman et al. 2015; Jussila et al. 2016) and a number of crayfish plague epidemics being caused by *A. astaci* strains carried and spread by the alien signal crayfish (Bohman et al. 2006; Viljamaa-Dirks et al. 2013; Jussila et al. 2014b; Jussila et al. 2015b). It has recently been discussed in Europe that the introduction of the alien signal crayfish might not have been the right solution (e.g., Gren et al. 2009a, 2009b; Holdich et al. 2009; Jussila et al. 2015b; Manfrin et al. 2018). The concern of the Finnish national fisheries authority has been less obvious (Ruokonen et al. 2018), though one of the main issues in Fennoscandia has been the potent threat of the alien signal crayfish to the remaining native noble crayfish stocks and the possibility that the noble crayfish might be totally eradicated (Bohman et al. 2006, 2011; Jussila et al. 2015b). The European Union's rigorous attitude on the harmful alien species is adding to this concern, not least by the implementation of the EU Regulation 1143/2014.

The aim of this paper is to introduce schemes regarding the *uncontrolled spreading* of the alien signal crayfish (*P. leniusculus*) as it replaces the declining native noble crayfish stocks. We present case studies as examples from Finland and Sweden, based on published reports and unpublished observations, and finally give a summary of the conclusions that these cases indicate regarding the spread of the alien signal crayfish. The focus is on practical impacts and effects of the alien species on native species and ecosystems.

CASE STUDIES FROM FINLAND

Stockings Enhance Uncontrolled Spreading of Alien Crayfish and Aphanomyces astaci

Since 1989, it has been suggested by the Finnish national and regional crayfisheries strategies that a so-called *controlled spreading* of the alien signal crayfish within designated water bodies would ensure that the spread of this alien crayfish would be restricted and controlled (Ruokonen et al. 2018). At the same time, crayfish have traditionally been sold live for consumption, even in supermarkets, and crayfish trappers have commonly been selling both live market-size crayfish for consumption and smaller crayfish for stocking. Furthermore, wider stocking of the alien signal crayfish has been promoted and the stocked population development has been optimistically described, leading to inflated production expectations (e.g., Jussila et al. 2015a; Ruokonen et al. 2018). In addition, private persons have even been transporting live alien crayfish to be temporarily held in water bodies close to their summer cottages for later processing and consumption, similar to what has been observed in Sweden (e.g., Edsman 2004). This has created a relaxed tradition of crayfish stockings long before the implementation of the so called *controlled spreading* scheme, as both native noble crayfish and alien signal crayfish have been released without either stocking licenses or consultations with fisheries authorities (Jussila et al. 2014a; Ruokonen et al. 2018). In the following paragraphs, we will give a few examples on what kind of outcomes have occurred in Finland due to the *uncontrolled spreading* of the alien signal crayfish.

The Kanta-Häme region has been used as one of the main examples of a success story for stocking alien signal crayfish and the establishment of a commercially productive alien signal crayfish stock and commercial trapping practices (e.g., Kirjavainen and Sipponen 2004; Jussila et al. 2014a). Within Kanta-Häme, this has led to an almost complete eradication of the remaining native noble crayfish populations, mainly due to the uncontrolled stockings of alien signal crayfish and the resulting crayfish plague epidemics (e.g., Kirjavainen and Sipponen 2004; Viljamaa-Dirks et al. 2013; Jussila et al. 2014a). The noble crayfish stocks have been disappearing, irregardless of the regional action plans in place and their attempts to conserve these stocks (e.g., Kirjavainen and Sipponen 2004; Jussila et al. 2015a; Ruokonen et al. 2018). At the same time, the Kanta-Häme region has been heavily promoted

as the main region for alien signal crayfish production with various public campaigns and press releases, including giving awards to private individuals for their promotion of alien signal crayfish. Recently, it has been reported that production has collapsed in half of the stocked alien signal crayfish populations (Jussila et al. 2014a), which has also led to the collapse of commercial crayfish marketing systems. The factors behind the collapses have been speculated as lower tolerance of alien signal crayfish against *A. astaci* infection, environmental stress (mainly high temperatures), and multiple infections (e.g., Aydin et al. 2014; Jussila et al. 2014a; Sandström et al. 2014; Bohman et al. 2016).

In Savo, Central Finland a few licensed stockings, carried out to investigate the establishment and survival of alien signal crayfish populations in the Central part of Finland, ultimately lead to the *uncontrolled spreading* of alien signal crayfish and numerous crayfish plague outbreaks (Figure 1). It seems that the prospect of being able to profit from trapping alien signal crayfish has been tempting and local people tend to assist the futrher spread of the species, in this case alien signal crayfish, on their own while also ignoring regional strategies or general opinion on how the crayfisheries should be locally managed. In addition, the general public have had difficulties in distinguishing noble crayfish from alien signal crayfish. Thus, the stocking of the alien signal crayfish were actually never the *controlled spreading* of the alien signal crayfish, as the regulations were ignored and the crayfish were stocked without proper licensing.

In the case of Lake Lentua (Kuhmo), the alien signal crayfish appeared in the northeastern part of Finland (coordinates 64.210556, 29.568056, WGS84), roughly 200 km north of the northern-most boundary area that was designated for alien signal crayfish introductions, which was designated and defined by the recently updated national crayfisheries strategy (Ruokonen et al. 2018). In this case, the alien signal crayfish were introduced by a local person, possibly unaware of the negative impact of the alien signal crayfish to the regional noble crayfish populations and the fact that the introduction was illegal (e.g., unlicensed), as the local fisheries authority would not have granted a license for the stocking of alien signal crayfish in that water body. Furthermore, the stocking was done in a water body which had a productive and well-known noble crayfish population downstream, a classic commercially exploited stock in the middle of a local town (Kuhmo). Its possible that the person carrying out the unlicensed introduction was actually aiming to increase the production of the noble crayfish in the region but could not tell the alien signal crayfish from the noble crayfish, resulting in this catastrophic mistake. That particular alien signal crayfish stock has been shown to be a chronic carrier of *A. astaci*.

One problem adding to the unlicensed stockings is that the general public does not necessarily distinguish alien signal crayfish from native noble crayfish, and even if they can tell the difference, they assume these crayfish are variations of the same species. This confusion still happens despite several informational campaigns on the proper management of the crayfisheries and the consequences of careless acts with the alien crayfish species. A recent intensive informational campaign, LIFE+ CrayMate during 2013–2016, might have had an impact, but that remains to be seen. Also, the recent collapse of several wild alien signal crayfish populations (Jussila et al. 2014a), and resulting publicity of the phenomenon, have increased awareness of the negative aspects of the alien signal crayfish.

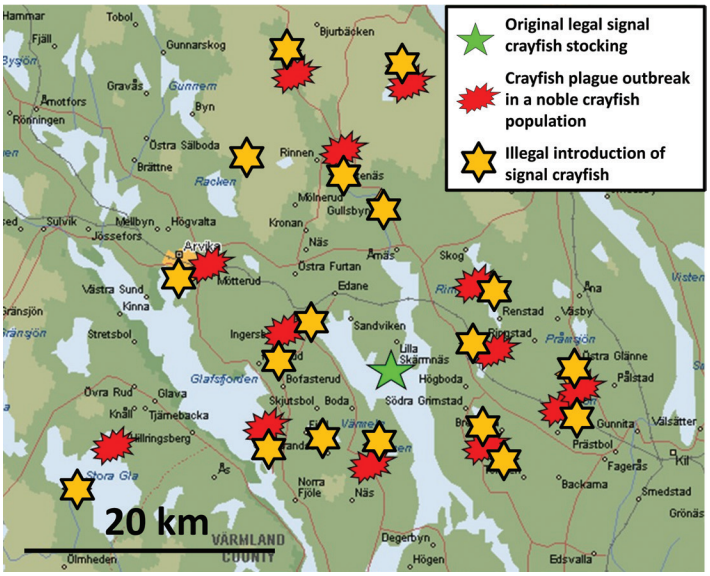

Figure 2. The relationship between the last legal introduction of signal crayfish in 1994, crayfish plague outbreaks and signal crayfish occurrences 10 years after in an area of Värmland County, Sweden. Information collected from The Rural Economy and Agricultural Societies, Värmland, County Administarative Board, Värmland, and Swedish Crayfish Database, Swedish University of Agricultural Sciences, Department of Aquatic Resources.

CASE STUDIES FROM SWEDEN

Stockings Into a Novel Area Enhance Uncontrolled Spreading of Alien Signal Crayfish and Aphanomyces astaci

The county of Värmland in the western part of central Sweden has had a restrictive policy and has only allowed four licensed introductions of alien signal crayfish into natural waters. For this reason, it had numerous, and productive, thus trappable populations of noble crayfish remaining even when a few crayfish plague incidents had occurred earlier. In 1994, just before the Swedish legislation got stricter and banned introductions of alien signal crayfish into new natural waters (Bohman et al. 2016), a last permit was given in Lake Värmeln (Figure 2). Ten years afterwards, a total of 17 noble crayfish populations in the vicinity of Lake Värmeln, in an almost symmetrical spreading area, had been struck by *A. astaci* infection and destroyed. The crayfish plague outbreak furthest away was 30 km from Lake Värmeln. In Värmland, the catchments run from north-northwest to south-southeast. Furthermore, the outbreaks occurred in 4 different watersheds and more than half of them happened upstream of the licensed alien signal crayfish introduction, excluding the possibility of natural spreading of alien signal crayfish.

Monitoring of lakes and running waters around 2004 revealed that 13 illegal introductions of alien signal crayfish had occurred. All these illegal introductions were close to recent crayfish

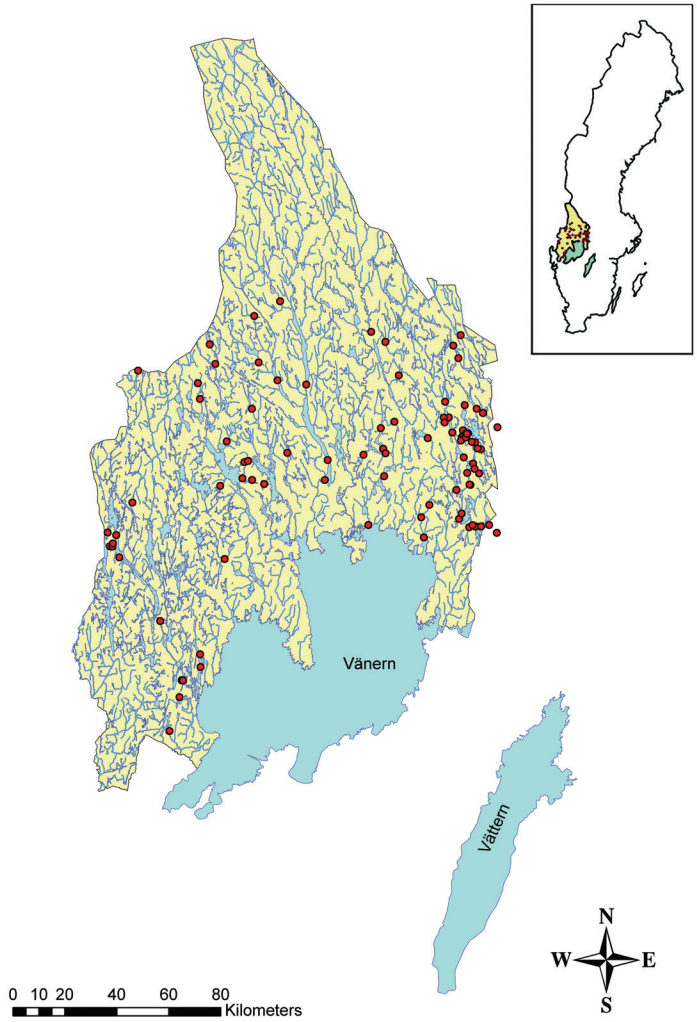

Figure 3. The observed illegal stocking of signal crayfish in the proximity of Lake Vättern (red dots) in the counties of Värmland and Dalsland in 1999–2005, Sweden.

plague outbreaks (Figure 2) and thus it was concluded that this could indicate that illegal introductions were the cause of *A. astaci* infections spreading. Later, the situation in the county of Värmland has gotten much worse, and out of 433 localities with noble crayfish in 2000, a total of 267 (62%) had disappeared by 2014. Instead, alien signal crayfish now appeared at 207 localities (Länsstyrelsen Värmland 2015; Bohman 2019), often in waters where noble crayfish had disappeared.

The Availability of Stocking Material for Illegal Introductions Enhance the Number of Ilegal Introductions

The second largest lake in Sweden, Lake Vättern, was stocked with alien signal crayfish starting in 1969. The population slowly increased and became trappable with commercial trapping starting in the early 1990s. In 1999, trapping was allowed for any Swedish citizen on state-controlled waters in Lake Vättern. People were allowed to trap with up to six traps during five weekends in August and September. Trapping in Lake Vättern soon became popular and thousands of people from all over Sweden participated. Also, poaching became more common, with people using too many traps, trapping outside the designated time period, and not respecting the minimum size of 10 cm TL. Lake Vättern was the only lake, out of 100,000 lakes in Sweden, open for public trapping. Trappers coming from far distances could return home with live crayfish. Since the minimum size regulation was sometimes ignored, small sized crayfish, not suitable for consumption, could easily be used for other purposes, such as illegal introductions. It is likely that live alien signal crayfish from Lake Vättern have been used for illegal introductions within both counties.

During the period of 1999–2005, a total of 82 illegal introductions of alien signal crayfish were discovered in the counties of Värmland and Dalsland in the western part of Sweden (Bohman 2019) (Figure 3). The distances were used as a proxy for likelihood or easiness of illegal introduction since more people are expected to take part the closer they live. The mean distance was calculated with Pythagoras' theorem from the center of Lake Vättern to the center of the municipality and sorted on municipality and year. An *illegal introduction index* was calculated by dividing the number of illegal introductions with the total number of waters for each municipality. There was a high negative correlation (P = 0.002) between illegal introductions in the municipality and the distance to Lake Vättern (Figure 4). The closer the lake or river was to Lake Vättern, the higher the probability of alien signal crayfish being illegally introduced to the water.

Swedish Fisheries Administration Attitude and Action Plans

The Swedish fisheries administration had a very positive attitude on introductions of alien signal crayfish in order to substitute the fisheries of noble crayfish lost due to the crayfish plague epidemics. More than 4000 permits for stocking into natural waters were issued from 1960 to 1994. The alien signal crayfish stockings were actively promoted by the authorities driven by overly optimistic expectations of the productivity of the alien signal crayfish. Quite soon, the initial assumption that alien signal crayfish were immune to *A. astaci* infection proved to be wrong (Unestam 1972). Instead, alien signal crayfish turned out to be a frequent chronic carrier of the disease. This resulted in a five-fold increase in the number of noble crayfish populations being lost due to crayfish plague epidemics in Sweden (Bohman et al. 2006). It also meant a loss of the fishery of noble crayfish in the southern part of Sweden. Nonetheless, permits continued to be given for alien signal crayfish introductions and it was not until 1994 that the attitude and the legislation was changed and as a result, permits were not given anymore to stock alien signal crayfish into natural waters, unless there was an established alien signal crayfish population already present based on a legal introduction (Edsman and Schröder 2009).

These actions and changes in the legislation have been implemented to try to counter the negative effects of the alien signal crayfish spreading:

1. No stocking permits for alien signal crayfish into new waters since 1994.
2. First action plan to preserve noble crayfish in 1998.
3. Import, transport and keeping of live alien crayfish from outside of Sweden banned in 2003.

4. County administration can assign specially protected areas for noble crayfish with restrictions on transport and trapping since 2005.
5. Second action plan to preserve the noble crayfish in 2009.
6. All introductions and farming of alien signal crayfish banned because of the EU Regulation 1143/2014 since 2016.
7. Third updated action plan to preserve noble crayfish in 2017.

Despite these measures, during the last two decades, the future for noble crayfish looks bleak in Sweden. The massive alien signal crayfish introductions (Bohman et al. 2006; Bohman 2019) have made almost all lakes and running waters in the southern and east-central parts of Sweden unsuitable for native noble crayfish. These are the parts of Sweden with the most suitable conditions and climate for freshwater crayfish. Therefore, noble crayfish are critically endangered and have been on the national red list since 2010, mainly due to 98% of the localities with noble crayfish having been lost during the last century. Finally, the introduction of alien signal crayfish into Sweden has not been economically viable, on the contrary, it has only incurred costs in the long run (Gren et al. 2009a, 2009b).

Finnish Fisheries Administration Attitude and Action Plans

The Finnish Fisheries administration has long been making and implementing strategies which allow and even promote spreading and stocking of the alien signal crayfish (e.g., Kirjavainen and Sipponen 2004; Ruokonen et al. 2018). The flexible nature of the national and regional crayfisheries strategies, especially under pressure from unlicensed stockings, has been a rule, allowing spreading of the alien signal crayfish to regions previously designated only for the native noble crayfish (Ruokonen et al. 2018). The loophole created within the first version of the Finnish national alien species strategy allowing private fishing rights owners to stock harmful alien signal crayfish in their water bodies (Jussila et al. 2015a) has created a funny situation where the strategy to limit the spread of the harmful alien species actually allowed it (e.g., Ruokonen et al. 2017). The Fishing Act (375/2015) imposes relevant strategies to be implemented in regional crayfisheries management strategies, thus enabling loopholes in other strategies to be included on a regional level and it also allowed further spreading of the harmful alien signal crayfish. Even the Finnish government fisheries administration is sometimes turning a blind eye on national legislation (Fishing Act (375/2015), Veterinary Act (441/2013) and Nature Conservation Act (1096/1996)) which bans the release of diseased animals, in this case *A. astaci* infected alien signal crayfish, into the wild and has thus been acting irresponsibly for a few decades.

Signal Crayfish in the Finnish Context

The catch of the alien signal crayfish in Finland has been estimated to have been between 2 and 6 million individuals for the past 15 years, according to the LUKE (former Game and Fisheries Research Institute). The catch was predicted to double every year during the 1990s thus enabling the catch figures of those estimated for noble crayfish before the first wave of the crayfish plague

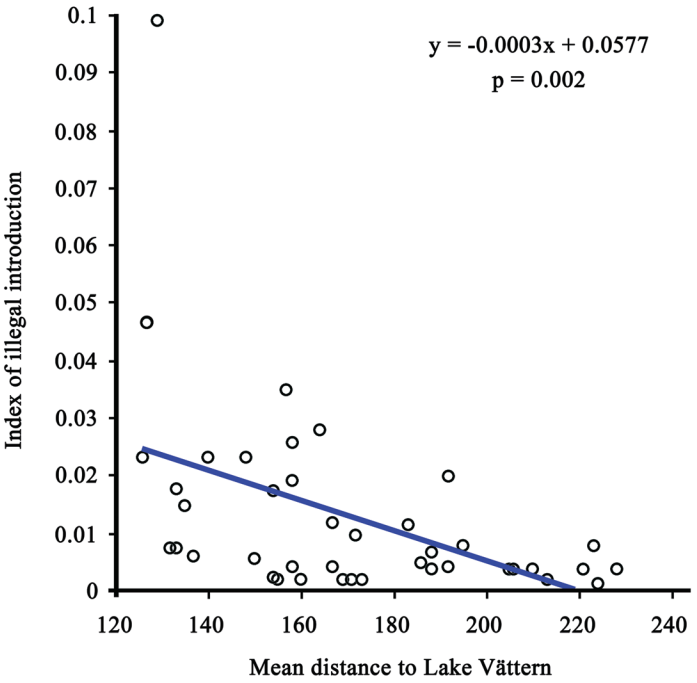

Figure 4. Correlation between the distance (km) from Lake Vättern to the places of signal crayfish introduction in the counties of Värmland and Dalsland, Sweden. The index of illegal introduction is calculated by dividing the number of illegal introductions with the total number of waters in each municipality. Thus, the index shows the proportion of waters in a municipality that have an illegal introduction.

epidemics in Finland (e.g., Westman and Nylund 1984; Jussila and Mannonen 2004). For a while, the alien signal crayfish catch was indeed increasing, and further stockings of the alien signal crayfish were promoted, especially in the southern part of Finland (e.g., Westman 2000; Kirjavainen and Sipponen 2004; Ruokonen et al. 2018). At the same time, there were increasing warnings of the wild alien signal crayfish stocks not performing as expected, with reports from Sweden indicating a similar development (e.g., Sandström et al. 2014). As alien signal crayfish still formed most of the the annual crayfish catches, it was presumed that the overall situation was stable and production failures an exception.

It took until the 2010s for the fisheries managers to realize and admit that alien signal crayfish, in addition to being a very efficient platform for the spread of *A. astaci*, was also experiencing population declines and crashes in the wild (e.g., Jussila et al. 2014a; Aydin et al. 2014). This caused increasing alarm among the fishing rights owners, who had repeatedly been told in the past that alien signal crayfish would be producing steady catches in the foreseeable future and would not suffer by being infected with *A. astaci*.

The alien signal crayfish has also had an impact on the traditional fishing practices, as dense alien signal crayfish populations interfere with the whitefish gillnet fishery (Jussila et al. 2015b). The dense populations also invade those shallow, rocky spots where gillnets for the whitefish (Coregonid species) fishery are laid. The alien signal crayfish tend to get tangled when trying to reach for the whitefish being caught in the gillnets. Fishermen

find this an obstacle for the fishery, due to added labor of removing the alien signal crayfish from their nets. This process sometimes breaks the gillnets and, in addition to being a nuisance, also causes economic losses for the fishermen. As an outcome of this, it is known that the fishermen have abandoned some of the traditional whitefish fishery sites.

The alien signal crayfish have been observed to consume fish eggs been laid on or in the bottom sediment. Several groups have shown that alien signal crayfish consume salmonid eggs and can affect the reproductive effort of the fish stocks, some of them being vulnerable or threatened (Peay et al. 2009; Setzer et al. 2011; Karjalainen et al. 2015). In lake Pyhäjärvi, the vendance (*Coregonus albula* (Linnaeus)) stock fluctuation cycle was disturbed after introduced alien signal crayfish stocks became dense. Even though the reasons behind the population dynamic changes are largely unknown in this case, it has been shown that alien signal crayfish may prey on vendance eggs (Karjalainen et al. 2015).

It should also be mentioned in this context that water bodies in Finland are normally very complicated networks of rivers and lakes that makes eradication of the unwanted alien crayfish almost impossible. The application of pesticides (Sandodden and Johnsen 2010; Peay et al. 2019), which would be efficient, would not be possible on a practical scale and would most certainly cause such damage to the aquatic ecosystem that their usage would be counterproductive. Thus, these means to minimize the damage that has been caused by unlicensed, and thus illegal, stockings have not been practiced so far. It is hard to imagine that they would ever be practiced in natural water bodies in Finland, even though measures for eradication alien signal crayfish from small and limited water bodies, e.g., RARITY LIFE+ Project (RARITY 2020), should be tested.

European Union Regulation 1143/2014

The European Union has taken a targeted approach to minimize of the negative impacts of the harmful alien species on European ecosystems and biodiversity (EU Regulation 1143/2014). This regulation aims to decrease the estimated annual 12-billion-euro damage to the environment that is caused by the alien species. In addition to defining alien species that could be harmful, the first list of most harmful alien species was agreed upon on December 4th, 2015 (EU List of IAS of Union concern 2017). This list includes five freshwater crayfish and one crab, the alien signal crayfish being one of these species.

The EU Regulation 1143/2014 has caused revision of the crayfisheries policy as well as alien species national level regulation especially in Finland. Until recently, the attitude in Finland towards alien signal crayfish has been relaxed and both national and regional crayfisheries strategies have even promoted further spreading of the alien signal crayfish (e.g., Ruokonen et al. 2018). With the novel EU Regulation 1143/2014, a total ban on further stockings and farming of the alien signal crayfish was implemented. Even though the EU Regulation 1143/2014 has been implemented loosely in Finland (e.g., import and transport of live alien signal crayfish allowed), the focus in the future could be shifted from the alien signal crayfish-based crayfisheries towards native noble crayfish-based crayfisheries with hopefully increased control against further spreading of both alien signal crayfish and *A. astaci*.

CONCLUSIONS

The mistake often repeated is the attempt to evaluate the success and impact of the introduced alien species when it is recently introduced and normally inhabiting a more or less empty niche within an ecosystem. Initially, everything seems to go as planned: growth is good, stocks increase and get productive, there are no health issues and the stocked ecosystems seem to function normally. The true impact of the alien species can be felt only when the species has settled in its novel environment and reached the level of the carrying capacity of its habitat. This is the point when the alien species needs to adapt to its novel environment and face the challenges of competition, resource deficiencies, increased stress and pathogens and parasites, which quite often are new to the species (e.g., Jussila et al. 2014a, 2016; Aydin et al. 2014; Edsman et al. 2015). In the case of the alien signal crayfish, after the period of 'all is well' which lasted some 20 years after the first introductions into Finland and Sweden, there have been several reports of wild alien signal crayfish stock failures, susceptibility to *A. astaci* infection and novel diseases (e.g., Aydin et al. 2014, Jussila et al. 2014a; Sandström et al. 2014; Edsman et al. 2015), all difficulties that are void in the alien signal crayfish original distribution area in North America.

An approach including careful multi-disciplinary risk assessment should be applied before the introduction of alien species, as has been widely discussed as part of political ecology (Robbins 2012). Even though the scope of most issues related to political ecology are wide and often include economic considerations, it is suggested, that the introductions of alien species should be considered from a broader perspective than strictly economical. Luckily, the EU has taken a firm stand here and implemented the alien species regulation, i.e., EU Regulation 1143/2014.

One should never underestimate the fact that alien species, once introduced and established to new environments, normally prove impossible to eradicate. The damage commonly resulting from the alien species introduction is normally only revealed, and also accepted, when the point of no return has already been passed and the only chance to limit the damage is to try to reduce the impact of the alien species on the environment. This should be viewed as a failure of the alien species introduction attempt, which was originally undertaken with the goal of improving the state of our crayfisheries.

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