Risk Assessment on *Pacifastacus leniusculus* (Dana, 1852)

Information regarding the relevant species, including-

(i) the taxonomy of the species, including its class, order, family, scientific name if known, genus, scientific synonyms and common names of the species;

Kingdom: Animalia
Phylum: Arthropoda
Subphylum: Crustacea
Class: Malacostraca
Subclass: Eumalacostraca
Superorder: Eucarida
Order: Decapoda
Suborder: Pleocyemata
Family: Astacidae
Genus: Pacifastacus
Subgenus: Pacifastacus (Pacifastacus)
Species: *Pacifastacus leniusculus* (Dana, 1852)
Common English name: North American signal crayfish

Description of the *Pacifastacus leniusculus*

The North American signal crayfish (*Pacifastacus leniusculus*) has a similar appearance to the noble crayfish, *Astacus astacus* (CABI, 2016). It is a lobster-like crustacean and is named for the conspicuous white, oval patch at the base of each claw where the two parts of the pincers meet. This distinctive marking, which is usually edged with blue, is the key characteristic used to identify *P. leniusculus*. The males can reach a length of up to 16cm from the tip of the rostrum to the end of telson. The females can usually achieve a maximum of up to 12cm, however much larger individuals have been recorded. Their size at maturity is around 6-9cm at an age of 2-3 years, although maturity can occur as early as 1 year (USA Fish and Wildlife Service, 2015). The body mass of *P. leniusculus* varies between 55 and 115 grams and they can sometimes have a life expectancy of up to 20 years under favourable conditions. (Hogan, 2016).

As can be seen from Figure 1, the cephalothorax of *P. leniusculus* is smooth with two pairs of post-orbital ridges, the anterior pair with an apical spine; and no spines on shoulders of the carapace behind the cervical groove (GISD, 2016). *Pacifastacus leniusculus* has rather robust, broad claws and the upper surface of this species is usually brown to greenish-brown, while the lower surface is often a contrasting bright orange or red. The species also has a distinctly smooth ridge running along the middle of the rostrum.
Figure 1: Signal crayfish (*Pasifastacus leniusculus*) Anterior View. Photo credits: commons.wikimedia.org

Figure 2 below shows that *P. leniusculus* has a smooth, reddish-brown exoskeleton and bright red undersides to the chelae. The exterior colour can sometime vary between brownish blue, reddish brown, and less commonly a plain brown. Young *P. leniusculus* resemble the adults (CABI, 2016).

Figure 2: Signal crayfish (*Pasifastacus leniusculus*) Posterior View. Photo credits: www.dcrt.org.uk

(ii) the originating environment of the species, including climate, extent of geographic range and trends;

Originating environment

According to CABI (2016) *P. leniusculus* is native to North America, mainly Canada and USA (California, Idaho, Montana, Nevada, Oregon, Utah and Washington). The *Pasifastacus leniusculus*, is the most widespread and one of the most successful crayfish invaders (Hudina, et al., 2016) and it has been introduced into many countries throughout Europe, which includes Austria, Belgium, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Latvia, Lithuania, Netherlands, Norway, Poland,
The introduction of *P. leniusculus* to these vast areas was motivated by firstly, commercial interests in creating a robust industry for harvesting this species; and also to provide additional food for fish. When the economically important crayfish populations of Europe were decimated by the crayfish plague in the early 20th century a number of *P. leniusculus* species were introduced in an attempt to replace the stocks. However *P. leniusculus* proved to be a voracious competitor and the outcome has produced an ecological nightmare by driving extinct a number of native crayfishes and producing an ecological imbalance (Lowery and Holdich, 1988).

**Habitat and biology**

*Pacifastacus leniusculus* prefers cool water along the shoreline of the various aquatic areas it inhabits and stoney bottoms which can provide hiding places as reported by Schuster *et al* (2010). The species requires refuges in the form of tree roots and rocks. Where the river bed provides little cover, the availability of cover in the banks determines the density of the population, with far greater densities found where the banks are protected with rocks. The species are highly adaptable and can be found in a wide variety of habitats including coastal and mountain streams and lakes, reservoirs, and major rivers. It will utilise both fast flowing stretches of the river as well as slow flowing reaches, with the juveniles found more commonly in the former, probably as a result of increased predation in deep water (Blake and Hart, 1993).

The species are also able to adapt to warmer waters, a pH above six and even slightly saline water bodies. The species tend to feed at night and rest in their hiding places during the day.

*Pacifastacus leniusculus* are very active and can migrate up and down rivers, as well as move around obstacles. Colonization of new areas is facilitated by the species ability to creep overland and around terrestrial barriers. Their rate of colonisation is about 1 km per year (GISD, 2016). It is considered to be a non-burrowing species but in Europe *P. leniusculus* is able to construct burrows under rocks or in rivers and lake banks. Their burrows can occur at very high organism densities which can compromise the stream-bank integrity and impact bank morphology causing them to erode and even collapse (Hogan, 2016).
Climatic conditions

_Pacifastacus leniusculus_ grow well in culture ponds and is tolerant of brackish water along the Pacific Coast and in salinities as high as 20 ppt. They are also able to tolerate high temperatures of up to 33°C which has allowed the species to prosper in many environments (CABI, 2016).

The optimal growing temperature for the species is approximately 20 °C but _P. leniusculus_ will copulate and spawn in warmer water (15 °C).

According to Kozak _et al_ (2009), daylight and water temperature regulate the moulting and reproduction of crayfish so environmental factors may affect the distribution of _P. leniusculus_ in many ways. Low water temperatures can delay hatching, and the juveniles may leave the female very late in the summer. Decreasing water temperatures induce the mating and spawning of the species and yearly variations in temperature may affect the success of these events. When the reproductive cycle is interrupted or unsuccessful over several successive years due to environmental reasons, self-sustaining _P. leniusculus_ populations cannot develop.

(iii) persistence attributes of the species, including reproductive potential, mode of reproduction, dispersal mechanisms

Behaviour

_Pacifastacus leniusculus_ is a nocturnal species and is known to take shelter under rocks and boulders, within tree roots or in burrows and cavities within banks. In the winter, adult species shelter in burrows and enter a state of torpor. These burrows are formed of many inter-connecting tunnels, and can be up to two metres deep (Wildscreen Archive, 2016).

The species is an extremely successful competitor, particularly within its introduced habitats. A large and hardy species, _P. leniusculus_ is more active and aggressive than other crayfish, and often has larger pincers. In addition, this species is thought to be able to tolerate relatively high temperatures, and may also be less vulnerable to winter conditions than native crayfish species. _Pacifastacus leniusculus_ is known to grow faster than any of the native European crayfish species. It was this quality, in addition to its resistance to crayfish plague, which made the signal crayfish an attractive commercial species and a popular replacement for disease-ravaged native crayfish populations in Europe. Unfortunately, the signal crayfish is a carrier of crayfish plague, and is thought to be responsible for passing the deadly disease to the white-clawed crayfish (_Austropotamobius pallipes_) in the UK (Wildscreen Archive, 2016).

Reproduction

According to Johnsen and Taugbol (2010). _P. leniusculus_ have a high rate of reproduction and the species has the typical life cycle of all members of the crayfish family Astacidae. Mating and egg-laying occurs during autumn and the egg numbers usually range from 200 to 400. After egg laying the female carries the eggs under the tail until hatching. Hatching time varies greatly depending on temperature. The eggs hatch into miniature crayfish that stay with the mother for three stages (two moults). In the third stage the juvenile crayfish gradually become more and more independent of the mother, adopting a solitary life. Size at maturity is usually 6-9 cm total-length (from tip of head to edge of tail-fan) at an age of 2-3 years. Competition and cannibalism can greatly affect survival in dense populations.
Dispersal mechanisms

Humans are the overall most important vector for the dispersal and spread of *P. leniusculus*. Due to fisheries in natural waters in most regions where it occurs, the species are easily accessible as stocking material. Within the watercourse, *P. leniusculus* are able to easily spread by own migration. Upstream migration rates of more than 1 km per year are reported from rivers in Finland and England whereas downstream spread can be faster. There are also indications that *P. leniusculus* may pass dams and waterfalls by walking on dry land and this behaviour is probably triggered by high density or other unfavourable conditions. This shows its potential for self-dispersal as normally, the crayfish would not leave the water and expose itself to great predation risk on land (Johnsen and Taugbol, 2010).

(iv) invasive tendencies of the species elsewhere and of close taxonomic relatives in South Africa and elsewhere;

*Pacifastacus leniusculus* has a range of ecological impacts on introduced environments that include competition and displacement of native crayfish, shelter displacement and consumption of fish; and an increased predation on snails. The presence of the species in a water body also results in a significant decrease in amphibians, macrophytes and invertebrates as these all serve as food sources for the species. *Pacifastacus leniusculus* are able to modify aquatic habitats through extensive bank burrowing. This in turn, results in greater bank erosion, stream shallowing, contaminant liberation from the sediment and also degradation of vegetative structures and associated habitats (Johnsen and Taugbol, 2010).

The species can also spread parasites and introduce novel diseases, to which native populations have no natural immunity. *Pacifastacus leniusculus* is itself immune to crayfish plague, but as a carrier of the disease it has contributed to the dramatic decline of populations of highly susceptible native European crayfish (Wildscreen Archive, 2016). The IUCN, Threatened List of Species, 2016 reports that in Europe, population declines of between 50% and 80% have been observed in the white-clawed crayfish (*Austropotamobius pallipes*) and 50% and 70% in the noble crayfish (*Astacus Astacus*).

(v) the history of domestic propagation or cultivation of the species, introductions and the extent of naturalisation in South Africa and elsewhere;

Capurro et al (2007) reported that the reasons for the historical introductions of alien crayfish stocks into natural waters were mainly due to the stocking of humans. There was a perceived need to replace the impoverished native crayfish fauna, to fill a vacant niche and to control aquatic water vegetation.

Accidental introductions have often been due to escapes from aquaculture facilities or from anglers using *P. leniusculus* as bait. The species is able to spread by natural migration within a watercourse and between migration barriers but most of the current reported spread is due to the illegal introductions by humans (Johnsen and Taugbol, 2010).

*Pasifastacus leniusculus* is not known to occur in South Africa but it has been sighted during compliance inspections by the Competent Authority of the Department of Environmental Affairs, Directorate Biosecurity. Using modelling applications by the Bureau of Rural Science (DAFF), the climate between the species, historical distribution and potential South African distribution is compared (shown in Figure 4 below). This Model indicates that the Western Cape region has a highly similar climate which can support the successful establishment of
introduced populations of *P. leniusculus* (highest climate match score: 8). The species is very adaptable and as some are already present in South Africa, efforts must be made to prevent them from further expanding their range and establishing detrimental population numbers.

![Climate match between South Africa and Europe for Pacifastacus leniusculus (signal crayfish)](http://www.agriculture.gov.au/)

(vi) nutritional or dietary requirements of the species and, where applicable, whether it has a specialist or generalist diet;

*Pacifastacus leniusculus* is an opportunistic polytrophic feeder (being herbivores, omnivores, predators and detritivores) as it will eat anything that is available, including other crayfish. The species diet was found to shift from plant material (alder, maple leaves) in adults; to aquatic insects (*Ephemeroptera, Plecoptera, Trichoptera* and *Diptera*) and also detritus in both adults and juveniles (CABI, 2016). According to GISD (2016), in some American populations, more plant material was consumed by adults whereas in a British river, cannibalism increased with size and *P. leniusculus* practised such cannibalism and consumed more animal than plant material.

(vii) the ability of the species to create significant change in an ecosystem;

*Pacifastacus leniusculus* is considered to be a non-burrowing species in North America but in Europe it constructs burrows in river and lake banks. As such, it is able to modify aquatic habitats through extensive bank burrowing, resulting in greater bank erosion and stream shallowing. *Pacifastacus leniusculus*, in Europe is associated with environmental changes, including habitat degradation (Harvey et al., 2011) and reductions in native macro invertebrate diversity (e.g. Jackson et al., 2014). Accordingly, Jackson et al., 2014 indicated that the invasive crayfish has stronger predatory impact than the native species *Austropotamobius pallipes* in Europe.
Crayfish burrowing can cause erosion of riverbanks as burrows can sometimes be up to 2m deep, with many inter-connecting tunnels that weaken the bank. This can also contribute to problems with flooding, livestock safety and stability of structures that are built on the banks (GISD, 2016). Crayfish also take refuges from salmonid fish and predate fish eggs, which could reduce the value of commercial fisheries.

As an opportunistic polytrophic feeder, *P. leniusculus* consumes detritus and in turn plays an important role in the degradation and mineralization of dead organic matter. The species exerts a significant grazing pressure on macrophytes, aquatic insects, snails, benthic fishes and amphibian larvae. Several studies indicate that *P. leniusculus* have a stronger impact on the food web structure than the noble crayfish (Johnsen and Taugbol, 2010).

The introduction of *P. leniusculus* in waterbodies has also had a negative impact on other native crayfish populations as they are more aggressive and more fertile. For example, the continued existence of *P. fortis* in the Pitt River of north-eastern California is threatened by the introduction of *P. leniusculus*. In Europe, *P. leniusculus* has outcompeted the noble crayfish for shelter and resources, leaving it more susceptible to predation. The spread of *P. leniusculus* throughout Europe has also enabled “crayfish plague” to spread as it is a vector of, and is immune to the fungal disease that essentially wipes out all native crayfish populations. In Britain, *P. leniusculus* has been found to prey upon the native crayfish *Austropotamobius pallipes*, thereby extirpating the local populations. The disappearance of several invertebrate communities in some rivers in the Thames catchment has also been attributed to *P. leniusculus*. The species is also known to have decimated Atlantic salmon populations. (CABI, 2016).

(viii) the potential to hybridise with other species and to produce fertile hybrids; and

According to Hobbs (1988), *P. leniusculus* is believed to have originally consisted of three isolated subspecies viz., *leniusculus*, *klamathenis* and *trowbridgii*. However, transplants by man mixed the allopatric populations of these three subspecies, resulting in their widespread hybridisation, and although individual characteristics of each one occasionally turn up in single populations it is regarded as being one species.

*Pacifastacus leniusculus* can also mate with noble crayfish, but the eggs are not fertile (Johnsen and Taugbol, 2010).

(iv) The presence of natural enemies, predators and competitors;

In Italy, teleost fish and *Perca* spp. are the only natural enemies and predators of *P. leniusculus* present in the Brugneto Lake. (Capurro et al., 2007).

In the UK, *P. leniusculus* is known to be predated by otters (*Lutra lutra*), American mink (*Mustela vison*) and predatory fish such as Atlantic salmon (*Salmo salar*) and European eels (*Anguilla anguilla*) (Wildscreen Archive, 2016). The rainbow trout (*Oncorhynchus mykiss*) has also been stated as an important predator of *P. leniusculus*.  


(v) The presence of potentially reproductive compatible species.

A risk assessment carried out in terms of sub-regulation (1) must identify-

(a) the probability that the species will naturalise in the area in which the restricted activity is to be carried out or in any other area elsewhere in the Republic;

If *P. leniusculus* is introduced into the waterways of South Africa, it will naturalise. The climate of South Africa as indicated by Figure 4 is similar to that of the species’ native and introduced ranges, where it has managed to thrive.

(b) the possible impact of the species on the biodiversity and sustainable use of natural resources-

The most severe effect of *P. leniusculus* is the extermination of the noble crayfish, caused by the transmission of the crayfish plague. Most, if not all *P. leniusculus* are infected by the crayfish plague. Thus, if a signal crayfish population is established in a watercourse, the crayfish plague is also established. Indigenous European crayfish species have no resistance against this disease and experience total mortality. American crayfish species on the other hand have co-evolved with the crayfish plague and developed defence systems making them a natural host for, and carrier of this parasitic disease (Johnsen and Taugbol, 2010). In addition, Invasive crayfish have negative effects upon aquatic macrophytes, amphibians, fish, and benthic aquatic macro invertebrates. Invasive crayfish may reduce the abundance of snails, dipterans, and chironomids, Trichoptera, Ephemeroptera, and Coleoptera, Cray-fish also affect other macro invertebrates indirectly through reduction of food sources (Moorhouse, et al., 2014).

The reproduction efficiency, feeding ecology, behavioural and ecological characteristics make *P. leniusculus* a highly invasive species. *Pacifastacus leniusculus* can co-exist with some indigenous crayfish species in Europe, but in the long run it usually out competes them. The rate of spread of *P. leniusculus* can vary from 0.2 km per year to 2.8 km per year (Capurro et al., 2007).

Although polytrophic in diet, faunal intake is preferred by this crayfish, which has caused major attrition to certain macro-invertebrates, benthic fish and aquatic vegetation. *P. leniusculus* has been shown to decimate Atlantic salmon populations. *Pacifastacus nigrescens*, which is endemic to the western USA, went extinct partially due to interspecific competition with *P. leniusculus*, which humans introduced into its range. *Pacifastacus leniusculus* has also caused a contraction in the range of the western USA narrowly endemic *P. fortis* (Hogan, 2016).

(c) the risks of the specimen serving as a vector through which specimens of other alien species may be introduced;

Schuster et al (2010) states that crayfish plague which is caused by the fungus-like organism *Aphanomyces astaci*, is listed in the top 100 of the “World’s Worst” invaders by the International Union for Conservation of Nature (IUCN). *Pacifastacus leniusculus* are carriers of this disease but are highly resistant to infection by it. The species are largely immune to its effects and live in a balanced host-parasite relationship with the parasite probably as a result of coevolution. As carrier to this disease, *P. leniusculus* introduction to new catchments directly contributes to infection in those catchments. Outbreaks of the crayfish plague in different water
catchments that do not contain *P. leniusculus* may even occur and spread by the use of damp fishing gear previously used in infected areas (Ibbotson and Furse, 1995).

*Pacifastacus leniusculus* are also found to be susceptible to infection with white spot syndrome virus (WSSV) according to Hogan (2016).

*Thelohania contejeani* has been found to infect signal crayfish in North America (McGriff and Modin, 1983).

d) the risks of the method by which a specimen is to be introduced or the restricted activity carried out serving as a pathway through which specimens of other alien species may be introduced; and

Importing specimens from other countries into South Africa, moving specimens from one locality to another in the short-term would be the pathway through which alien species may be introduced and spread. The nature of the restricted activities;

- Importing into the Republic – species from the country of origin of the introduced specimens could be introduced at the same time.
- Growing, breeding or in any other way propagating any specimen of a listed invasive species, or causing it to multiply. If introduced specimens transmit bacteria or viruses to offspring, and these are sold, the introduced organisms could be spread.
- Selling or otherwise trading in, buying, receiving, giving, donating or accepting as a gift, or in any way acquiring or disposing of any specimen of a listed invasive species. Selling introduced individuals of *P. leniusculus* that serve as vectors for other alien species could spread and introduce a number of unwanted alien invasive species.
- Conveying, moving or otherwise translocating any specimen of a listed invasive species
- Spreading or allowing the spread of any specimen of listed invasive species;
- Releasing any specimen of a listed invasive species.

The only pathway of entry is illegally via the aquarium or aquaculture trade and this species should be detected and destroyed at import.

(e) any measures proposed in order to manage the risks.

There are no successful documented techniques known for the management of *P. leniusculus* on a large scale.

Mechanical - Traps

Trapping as a management tool is well suited to deep still waters, and will regulate crayfish populations if carried out on a large enough scale. One must also consider that trapping is size selective, with the result that smaller individuals often elude such traps. Extensive trapping may only reduce population density and slow down the speed at which it spreads naturally, but it is not an effective control method (Johnsen and Taugbol, 2010) Moorhouse, et al., 2013 further indicated that the removal trapping of signal crayfish from UK rivers lowered signal of cray-fish densities would result in increases in macro invertebrate numbers and taxon richness.

The British Government is now encouraging anglers to kill any *P. leniusculus* that they catch (Wildscreen Archive, 2016).

Chemical
When *P. leniusculus* is established in a large water body, there is no successfully proven way of eradication. However, in a very small, enclosed waterbody insecticides, chemical treatment and draining can be applied (Johnsen and Taugbol, 2010).

BETAMAX VET is a cypermethrin-based pharmaceutical and is toxic to cold-water fish, aquatic insects and crustaceans, whereas other invertebrates, mammals, and birds are relatively tolerant towards this group of chemicals (Sandodden and Johnsen, 2009). When a population of *P. leniusculus* is restricted to small isolated ponds, the chances of eradication, using a combination of chemical treatment and draining was believed to be good. Reports indicate that BETAMAX VET can be a useful tool in only managing alien crayfish populations in a limited water body, however, eradication of non-native crayfish populations in very large watersheds is unlikely to succeed (Sandodden and Johnsen, 2009).

Preventing the further introduction of *P. leniusculus* into new bodies of water is the most important element of future decision-making regarding this species. Public awareness of the ecological risks that this crayfish species poses and identifying new populations are the key components to arrest the spread of *P. leniusculus*. Legislation has been invoked to in Britain, which labels the species as a pest and bans the keeping of it in Scotland, Wales and much of England (Hogan, 2016)

3. Based on the information in sub-regulations (1) and (2), a risk assessment must consider-

(a) the likelihood of the risks being realised;

Loss of South African biodiversity is expected as *P. leniusculus* will invade and outcompete other crayfish species. This species is able to reach impressive densities in a short time (Vaeben and Hollert, 2015). They are vagrant, aggressive, they prey on a wide trophic spectrum, have a high reproductive potential, and grow larger and at a faster rate than other crayfish species. Escape from the farms is common and these escapees have been very successful at establishing populations in the wild (Lowery and Holdich, 1988). Successful transfers for aquaculture will almost certainly lead to the establishment of breeding populations in the natural environment. *Pacifastacus leniusculus* kept in overcrowded conditions in farm ponds can migrate out of these and travel several miles across land, colonising adjacent water bodies.

(b) the severity of the risks and consequences of the realisation of the risks for other species, habitats and ecosystems;

*Pacifastacus leniusculus* is an invasive and widespread species. They are able displace native crayfish by out-competing them and often growing to a larger size. This species is also resistant to the crayfish plague but is a carrier of the disease and is able to thrive in a wide range of habitats (Schuster et al., 2010). *Pacifastacus leniusculus* have proven to cause a reduction in many native fish populations as they displace such fish from their shelters thereby putting them at a higher risk for predation (Vaeben and Hollert, 2015).

Documented information indicated that *P. leniusculus* lower the abundance and diversity in aquatic vegetation and invertebrates in areas they invade. They have the potential to decimate benthic invertebrate populations as well as submerged plants. The benthic invertebrate populations serve as a necessary food source whereas the submerged plants is an important part of the habitat of fish. The submerged plants functions as a hiding space for *P. leniusculus* fry as well as their prey. The species are also suspected to have suspended effects of phytoplankton, certain algae and animals due to bioturbation (Vaeben and Hollert, 2015).
In areas where *P. leniusculus* are present, there has also been increased predation on aquatic snails. The snails’ decrease led to a corresponding increase of periphyton biomass due to reduced grazing (Væben and Hollert, 2015).

As the species is reported to be salinity tolerant, it could impact estuarine environments (CABI, 2016).

(c) the potential costs associated with the control of the species to minimise harm to biodiversity; and

According to Sandodden and Johnsen (2009), the total cost for a project undertaken using chemicals was 800000 Norwegian kroner or approximately 95 000 Euros (October 2009 values). This however, does not include estimates of total water volume, and draining of the ponds.

There are no other conclusive reports indicative of the cost of controlling *P. leniusculus* but it is estimated to run very high. All projects implemented will have to be at a trial phase since no definite control method has been successfully established. There will also be added expenses incurred for monitoring and evaluation of the project and any subsequent eradication efforts put forth.

(d) options for minimising the potential risks.

In South Africa the *Pacifastacus leniusculus* (signal crayfish) is currently listed as a prohibited species. However, since it has been detected in the country during inspections by DEA (Environmental Management Inspectors), the listing will be changed accordingly when the Alien and Invasive Species Lists are amended.

References

URLS:


Wildscreen Archive (2016). Signal Crayfish (*Pacifastacus leniusculus*)

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**Annexure C: Suggested Summary: *Pacifastacus leniusculus***

Invasive status: ☑ Invasive ☐ Under surveillance ☐ Not invasive [If invasive, fill in the rest of the section.]

Range:

☑ Whole of South Africa

☐ Specific Provinces/Biomes:

☐ Specific habitats:
Ability to spread:
- High:
- Moderate
- Mild

Ability to control:
- Eradication possible
- Effective control possible
- Very difficult to control in areas invaded
- Beyond control in areas invaded:

Impacts:
- High
- Moderate
- Low

Known utility:
- High
- Moderate
- Low

Recommended Category:
- Category 1a
- Category 1b
- Category 2
- Category 3
[Tick as many as apply, where differentiation needed.]

Recommended Restricted Activities:
- a. Importing into the Republic, including introducing from the sea, any specimen of a listed invasive species.
- b. Having in possession or exercising physical control over any specimen of a listed invasive species.
- c. Growing, breeding or in any other way propagating any specimen of a listed invasive species, or causing it to multiply.
- d. Conveying, moving or otherwise translocating any specimen of a listed invasive species.
- e. Selling or otherwise trading in, buying, receiving, giving, donating or accepting as a gift, or in any way acquiring or disposing of any specimen of a listed invasive species.
- f. Spreading or allowing the spread of any specimen of a listed invasive species.
- g. Releasing any specimen of a listed invasive species.
- h. The transfer or release of a specimen of a listed invasive fresh-water species from one discrete catchment system in which it occurs, to another discrete catchment system in which it does not occur; or, from within a part of a discrete catchment system where it does occur to another part where it does not occur as a result of a natural or artificial barrier.
- i. Discharging of or disposing into any waterway or the ocean, water from an aquarium, tank or other receptacle that has been used to keep a specimen of an alien or a listed invasive species.
- j. Catch and release of a specimen of a listed invasive fresh-water fish or listed invasive fresh-water invertebrate species.
- k. The introduction of a specimen of an alien or a listed invasive species to off-shore islands.
- l. The release of a specimen of a listed invasive fresh-water fish species, or of a listed invasive fresh-water invertebrate species, into a discrete catchment system in which it already occurs.