Appendix A

Harmonia^{+PL} – procedure for negative impact risk assessment for invasive alien species and potentially invasive alien species in Poland

QUESTIONNAIRE

A0 | Context

Questions from this module identify the assessor and the biological, geographical & social context of the assessment.

a01. Name(s) of the expert(s):

first name and family name

1. Przemysław Śmietana
2. Maciej Bonk
3. Wojciech Solarz

acomm01. Comments:

	degree	affiliation	assessment date
(1)	dr hab.	Department of Plant Ecology and Environmental Protection, Faculty of Biology, University of Szczecin	15-12-2017
(2)	mgr	Institute of Nature Conservation of the Polish Academy of Sciences in Cracow	18-12-2017
(3)	dr	Institute of Nature Conservation of the Polish Academy of Sciences in Cracow	18-12-2017

a02. Name(s) of ***the species*** under assessment:

Polish name: Rak luizjański

Latin name: ***Procambarus clarkii*** Girard, 1852

English name: Red swamp crayfish

Współfinansowano w ramach projektu nr POIS.02.04.00-00-0100/16 pn. *Opracowanie zasad kontroli i zwalczania inwazyjnych gatunków obcych wraz z przeprowadzeniem pilotażowych działań i edukacją społeczną* ze środków Unii Europejskiej w ramach Programu Infrastruktura i Środowisko 2014-2020

acomm02.	Comments:

Polish name (synonym I) –	Polish name (synonym II) –
Latin name (synonym I) *Cambarus clarkii*	Latin name (synonym II) *Scapulicambarus clarkii*
English name (synonym I) Red swamp crawfish	English name (synonym II) –

a03. **Area** under assessment:

Poland

acomm03.	Comments: –

a04. **Status** of *the species* in Poland. *The species* is:

	native to Poland
	alien, absent from Poland
	alien, present in Poland only in cultivation or captivity
X	alien, present in Poland in the environment, not established
	alien, present in Poland in the environment, established

aconf01.	Answer provided with a	low	medium **X**	high	level of confidence

acomm04.	Comments: Species found in aquarium cultures, available in online and direct trade (Bonk and Solarz 2017, Śmietana 2018 - A), both at a decorative and food grade (Śmietana 2018 - A). Single case of catching, wherein it was found in open waters in Greater Poland Voivodeship (Urbaniak 2014 - A). Since there are no indications that the species could reproduce there, it should be considered as a one-time release, probably by an aquarist.

a05. The impact of *the species* on major domains. *The species* may have an impact on:

X	the environmental domain
	the cultivated plants domain
X	the domesticated animals domain
X	the human domain
X	the other domains

acomm05.	Comments: Red swamp crayfish is characterized by extremely polarized life strategy type – r (short life duration, fast growth rate, high reproduction rate) (Huner 1988, Correia 1995, Barbaresi and Gherardi 2000, Fishar 2006 - P), which makes it able strongly to affect the natural environment in places of presence, including those where it was introduced by man. (Rodríguez et al. 2007 - P). As a result of introducing the red swamp crayfish, the aquatic ecosystems of the Donana National Park (Spain) have been drastically changed (Gutierrez-Yurita et al. 1998 - P). Negative effect of the red swamp crayfish on algae, macrophytes, various groups of invertebrates, including other crayfish and fish was found In areas where the species is not native (Twardochleb et al. 2013 - P). Through the intensive digging of burrows (Correia and Ferreira 1995, Barbaresi et al. 2004 - P), it may threaten the stability of ground water structures, e.g. dikes (Correia and Ferreira 1995 - P), and may cause intense changes in the natural banks of watercourses (Strużyński 2007 and works cited therein - P) and turbidity of water (Rodríguez i in . 2003). Due to being a vector of pathogens and parasites of vertebrates, including humans, the presence of this species is associated with a threat to human and animal health (Hunner 1988). For example, the species is a carrier of the crayfish plague.

A1 | Introduction

Questions from this module assess the risk for *the species* to overcome geographical barriers and – if applicable – subsequent barriers of captivity or cultivation. This leads to *introduction*, defined as the entry of *the organism* to within the limits of *the area* and subsequently into the wild.

a06. The probability for ***the species*** to expand into Poland's natural environments, **as a result of self-propelled expansion** after its earlier introduction outside of the Polish territory is:

	low
X	medium
	high

aconf02.	Answer provided with a	low	medium	high **X**	level of confidence

acomm06. Comments:

The analysis of the species' growth in Europe indicates rapid rate of its propagation in Mediterranean climate countries. It seems, however, that this ability decreases with the cooling climate, i.e. towards the north. For example, two sites of this species located in the vicinity of Berlin and near the Czech-German border (closest to the Polish border), known before 2005 (Carral et al. 2006 - P), have not yet resulted (Kouba et al. 2014 - P) in further expansion of the red swamp crayfish in Central Europe.

a07. The probability for *the species* to be introduced into Poland's natural environments by **unintentional human actions** is:

	low
	medium
X	high

aconf03.	Answer provided with a	low	medium	high **X**	level of confidence

acomm07. Comments:

Due to the high resistance of the species to external conditions, including the high capability of surviving dry periods (Barbaresi and Gherardi 2000 - P), and the possibility of long-term breathing with atmospheric air (McMahon and Stuart 1999 - P), it is possible to transfer the species with all types of equipment used in waters of southern Europe. There is also a high probability of introducing this species in case of imports of fish stocks, mainly carp. In total, this probability may exceed 10 cases per decade.

a08. The probability for *the species* to be introduced into Poland's natural environments by **intentional human actions** is:

	low
	medium
X	high

aconf04.	Answer provided with a	low	medium	high **X**	level of confidence

acomm08. Comments:

The species is relatively easily available in pet trade and relatively easy to breed (effective breeding). Therefore there is an extremely high risk of introducing it to natural waters as a result of arbitrary introductions. The probability is much higher than 10 cases per decade. In Poland, it was found that this species was introduced into open waters (Urbaniak 2014 - A). However, there is no data indicating the establishment of the species in national waters in Poland. In addition, the species tolerates long-term transport, creating the threat of private

	import associated with tourism to the Mediterranean countries (especially Spain). Breeding in ponds cannot be excluded, which may favor entering other open waters.

A2 | Establishment

Questions from this module assess the likelihood for *the species* to overcome survival and reproduction barriers. This leads to *establishment*, defined as the growth of a population to sufficient levels such that natural extinction within *the area* becomes highly unlikely.

a09. Poland provides **climate** that is:

	non-optimal
X	sub-optimal
	optimal for establishment of *the species*

aconf05.	Answer provided with a	low	medium	high **X**	level of confidence

acomm09. Comments:

Current species displacement in Europe indicates that this species prefers the climatic conditions found in southern Europe (Carral et al. 2006 - P). A similar conclusion can be drawn when analyzing maps of climate similarity, however, the permanent presence of this species in positions in the Netherlands, northern France and Italy (Kouba et al. 2013 - P) (subalpine lakes) (Piscia et al. 2011 - P), as well as in colder areas of the USA and Japan (Carral et al. 2006 - P), indicates that there are potentially favorable conditions for the occurrence of permanent populations of this ecologically flexible species in Poland. This is confirmed by research into the ecology of this species (e.g. Gutierrez-Yurita et al. 1998 and works cited therein - P).

Locally, there may be even optimal thermal conditions in Poland, e.g. in heated waters near thermal power plants.

a10. Poland provides **habitat** that is

	non-optimal
	sub-optimal
X	optimal for establishment of *the species*

aconf06.	Answer provided with a	low	medium	high **X**	level of confidence

acomm10. Comments:

Having high adaptation abilities to habitat conditions, at the same time characterized by high tolerance to pollution levels (Del Ramo et al. 1987, Pisicia et al. 2011 - P), salinity, effects of eutrophication (Gutzmer and Tomasso 1985, MacMahon 2002 - P) and a large range of occupied habitats (e.g. Gutierrez-Yurita et al. 1998, Dana et al. 2011 - P), actually covering all types of waters, including submountain streams, this species will not encounter habitat barriers limiting the possibility of permanent occurrence of its population. However, it prefers shallow wetlands that are well-heated. Potential best habitat conditions for the species are present in old river beds and natural eutrophic water reservoirs, natural dystrophic ponds, and in flooded muddy river banks. Furthermore, shallow, warm fish ponds and heat channels in power plants, as well as combined heat and power plants may be particularly susceptible to colonization.

A3 | Spread

Questions from this module assess the risk of *the species* to overcoming dispersal barriers and (new) environmental barriers within Poland. This would lead to spread, in which vacant patches of suitable habitat become increasingly occupied from (an) already-established population(s) within Poland.

Note that spread is considered to be different from range expansions that stem from new introductions (covered by the Introduction module).

a11. The capacity of *the species* to disperse within Poland by natural means, **with no human assistance**, is:

	very low
	low
X	medium
	high
	very high

aconf07.	Answer provided with a	low	medium **X**	high	level of confidence

acomm11. Comments:

Population expansion (Data type: B)

In case of access to river systems in their lower sections, there is a possibility of rapid species expansion, due to species'fast propagation abilities (Barbaresi et al. 2004 - P). This is particularly dangerous in locations with operating heat and power plants, and other industry emitting thermal pollutions. Under warmed water conditions, it forms permanent populations, such as in Austria (locality: Warmbad Villach; Pockl et al. 2006 - P). However, there is no accurate data on the pace of population spread.

a12. The frequency of the dispersal of *the species* within Poland by **human actions** is:

	low
	medium
X	high

aconf08.	Answer provided with a	low	medium	high **X**	level of confidence

acomm12. Comments:

In case of this species, there is a potentially high risk of spread by humans. So far, however, no permanent sites of this species have been found in Poland. Nevertheless, there was one observation of a specimen of this species in the Greater Poland region (Urbaniak 2014 - A). The author of the observations considered that it is rather a one-off incident involving letting the crayfish enter the river, rather than the presence of a permanent population. There are also possible cases of escaping from the backyard ponds, if the species is introduced to them beforehand. Due to the frequent occurrence in aquarium pet trade, potential use as fishing baits, it should be assumed that events involving the spread of a species by man in case of its presence in waters will occur relatively often. Incidental spread, e.g. with fishing equipment, should also be considered. Having analyzed the foregoing conditions, more than 10 cases of transferring a specimen of this species over a distance greater than 50 km are expected per decade).

A4a | Impact on the environmental domain

Questions from this module qualify the consequences of *the species* on wild animals and plants, habitats and ecosystems.

Impacts are linked to the conservation concern of targets. Native species that are of conservation concern refer to keystone species, protected and/or threatened species. See, for example, Red Lists, protected species lists, or

Annex II of the 92/43/EWG Directive. Ecosystems that are of conservation concern refer to natural systems that are the habitat of many threatened species. These include natural forests, dry grasslands, natural rock outcrops, sand dunes, heathlands, peat bogs, marshes, rivers & ponds that have natural banks, and estuaries (Annex I of the 92/43/EWG Directive).

Native species population declines are considered at a local scale: limited decline is considered as a (mere) drop in numbers; severe decline is considered as (near) extinction. Similarly, limited ecosystem change is considered as transient and easily reversible; severe change is considered as persistent and hardly reversible.

a13. The effect of *the species* on native species, through **predation, parasitism or herbivory is**:

	inapplicable
	low
	medium
X	high

aconf09.	Answer provided with a	low	medium **X**	high	level of confidence

acomm13. Comments:

Through intense feeding, this species strongly affects water insects, molluscs, eggs and developmental stages of amphibians and fish, causing a serious threat to their presence (Gutierrez-Yurrita et al. 1998, Reynolds 2011 - P). In Spain, this species is, for example, responsible for the crowding out of native white-clawed crayfish (*Austopotamobius pallipes*) found in Annex II of the Habitat Directive. Due to the strong impact on biocenosis, red swamp crayfish can also demonstrate negative effect on other species of special care (however, it is difficult to state clearly that, due to the overlap of ecological niches, one can mention the northern crested newt *Triturus cristatus* - Annex II of the Habitat Directive). Through herbivorousness, it can cause strong changes in the species structure of plant communities (Gutierrez-Yurita et al. 1998, Gherardi and Lazzara 2006, Twardochleb et al. 2013 - P) e.g. 3260 - water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation, 3150 - Natural eutrophic lakes with *Magnopotamion* or *Hydrocharition* - type vegetation, it may also have a negative effect on rare or endangered plant species, for example the hardly-preserved European waterclover*Marsylea quadrifolia* (Polish Plant Red Data Book, EW category) (Kaźmierczakowa, 1993), water caltrop *Trapa natans* (IUCN Red List: LC).

a14. The effect of *the species* on native species, through **competition** is:

	low
	medium
X	high

aconf10.	Answer provided with a	low	medium	high **X**	level of confidence

acomm14. Comments:

The red swamp crayfish is a strong competitor for European species (Gherardi and Cioni 2004, Gherardi 2006 - P). Due to the pressure of this species on habitats, it demonstrates great food competition for many species of aquatic organisms, mainly fish, such as: amur bitterling *Rhodeus sericeus*, European weatherfish *Misgurnus fossilis*, lake minnow *Eupallasella percnurus* (Annex II of the Habitat Directive). It may be a potential competitor of aquatic herbivorous birds (Gherardi and Acquistapace 2007 - P), for example, gadwall *Mareca strepera*, garganey *Spatula querquedula.* Due to similar habitat preferences, it can be a strong threat to Danube crayfish (*Astacus leptodactylus*) present in open waters (ponds) as well as cultures. In addition, in case of penetrating the noble crayfish *Astacus astacus* habitats, it will compete with this threatened (IUCN) species.

a15. The effect of *the species* on native species, through **interbreeding** is:

X	no / very low
	low
	medium
	high
	very high

aconf11.	Answer provided with a	low	medium	high **X**	level of confidence

acomm15. Comments:

This species does not interbreed with any native species in the strict sense of the word. Mating phase interference is possible when co-occurring with any native species (the interference includes males of this species mating with females of native crayfish, destroying eggs on their abdomens or mutilating females) (Śmietana 2018 - A).

a16. The effect of *the species* on native species by **hosting pathogens or parasites** that are harmful to them is:

	very low
	low
	medium
	high
X	very high

aconf12.	Answer provided with a	low	medium	high **X**	level of confidence

acomm16. Comments:

This species is a ihost of many parasites (helminths) of vertebrate animals (Carral et al. 2006 - P). It was confirmed that this species carries flukes of the *Paragonimus* genus (Philips 2016 - P), which are dangerous for canids, felines and humans. It is the carrier of the crayfish plague *Aphanomyces astacia*, mentioned on the OIE list (Gherardi 2006, Aquiloni et al. 2011, Kozubíková-Balcarová et al. 2013 - P) and a virus causing fresh water crayfish vibriosis. It is therefore a serious threat to the noble crayfish *Astacus astacus* (Polish Red Data Book of Animals and IUCN - VU threatened (Krzywosz and Śmietana 2004 - P).

a17. The effect of *the species* on ecosystem integrity, by **affecting its abiotic properties** is:

	low
	medium
X	high

aconf13.	Answer provided with a	low	medium	high **X**	level of confidence

acomm17. Comments:

The species strongly affects the structure of the bottom and banks in areas of presence by digging deep burrows (up to 2-meter deep), forming entire mining systems (up to several-meters long). This phenomenon, associated with the strong consumption of aquatic plants, leads to an undesirable increase in water turbidity and a decrease in sunlight penetration (Correia and Ferreira 1995, Barbaresi et al. 2004, Anastácio et al. 2005, Rodríguez et al. 2007, Strużyński 2007 and works cited therein, Matsuzaki et al. 2009 - P). Depending on the scale, the effects of the species may be difficult to reverse. However, it is difficult to predict the final result, nevertheless this species can cause disturbances of this type in dystrophic reservoirs and flooded muddy river banks, and in other areas particularly vulnerable to establishment, i.e. shallow, severely heating fish ponds and channels of warm power plants, and combined heat and power plants. This effect can be noted in various water habitats, in particular: 3260 - water courses of plain to montane levels with the *Ranunculion fluitantis*

	and *Callitricho-Batrachion* vegetation, 3150 - Natural eutrophic lakes with *Magnopotamion* or *Hydrocharition* - type vegetation.

a18. The effect of *the species* on ecosystem integrity, by **affecting its biotic properties** is:

	low
	medium
X	high

aconf14.	Answer provided with a	low	medium	high **X**	level of confidence

acomm18. Comments:

The species affects a number of organisms, including the plant cover shaping the nature of aquatic habitats (e.g. Gutierrez-Yurita et al. 1998, Twardochleb et al. 2013 - P). The population of this species in Lake Chozas in the north-western Spain, caused by introduction, resulted in reduction of: 99% of vegetation, 71% of invertebrate fauna, 83% of amphibians and 52% of water birds (Rodríguez et al. 2007 - P). The effects can demonstrate extremely large scale, frequency and be difficult to reverse in oxbow lakes and natural eutrophic water reservoirs, natural dystrophic reservoirs, and flooded muddy river banks. They may concern in particular habitats: 3260 - water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation, 3150 - Natural eutrophic lakes with *Magnopotamion* or *Hydrocharition* - type vegetation These changes can be difficult to reverse.

A4b | Impact on the cultivated plants domain

Questions from this module qualify the consequences of *the species* for cultivated plants (e.g. crops, pastures, horticultural stock).

For the questions from this module, consequence is considered 'low' when presence of *the species* in (or on) a population of target plants is sporadic and/or causes little damage. Harm is considered 'medium' when *the organism's* development causes local yield (or plant) losses below 20%, and 'high' when losses range >20%.

a19. The effect of *the species* on cultivated plant targets through **herbivory or parasitism** is:

	inapplicable
X	very low
	low
	medium
	high
	very high

aconf15.	Answer provided with a	low	medium	high **X**	level of confidence

acomm19. Comments:

This species causes large losses in rice crops (Barbaresi and Gherardi 2000, Anastácio et al. 2015 - P). In climatic conditions of central Europe, at the moment there are no plants grown on which the species could feed.

a20. The effect of *the species* on cultivated plant targets through **competition** is:

X	inapplicable
	very low
	low
	medium
	high
	very high

aconf16.	Answer provided with a	low	medium	high	level of confidence

acomm20. Comments:

The species is an animal, therefore it is not a plant competitor.

a21. The effect of *the species* on cultivated plant targets through **interbreeding** with related species, including the plants themselves is:

- [X] inapplicable
- [ ] no / very low
- [ ] low
- [ ] medium
- [ ] high
- [ ] very high

aconf17.	Answer provided with a	low	medium	high	level of confidence

acomm21. Comments:

The species is an animal, therefore it does not interbreed with plants.

a22. The effect of *the species* on cultivated plant targets by **affecting the cultivation system's integrity** is:

- [X] very low
- [ ] low
- [ ] medium
- [ ] high
- [ ] very high

aconf18.	Answer provided with a	low	medium **X**	high	level of confidence

acomm22. Comments:

The effect of this species on crops by changing the water conditions caused by damage to dams or embankments by digging burrows (Kouba et al. 2013), which mainly concerns crops located near water.

a23. The effect of *the species* on cultivated plant targets by hosting **pathogens or parasites** that are harmful to them is:

- [X] very low
- [ ] low
- [ ] medium
- [ ] high
- [ ] very high

aconf19.	Answer provided with a	low	medium	high **X**	level of confidence

acomm23. Comments:

There are no known parasites and plant pathogens transmitted by this species.

A4c | Impact on the domesticated animals domain

Questions from this module qualify the consequences of *the organism* on domesticated animals (e.g. production animals, companion animals). It deals with both the well-being of individual animals and the productivity of animal populations.

a24. The effect of *the species* on individual animal health or animal production, through **predation or parasitism** is:

	inapplicable
	very low
X	low
	medium
	high
	very high

aconf20.	Answer provided with a	low	medium **X**	high	level of confidence

acomm24. Comments:

Potentially large losses due to predation in carp production are possible, in case of co-occurrence in breeding ponds, especially fry ponds. There is no known effect on other fish bred in Poland. Undesirable species in crayfish breeding, potentially particularly dangerous especially in case of breeding 0+ and 1 age groups of Narrow-clawed crayfish (Śmietana 2018 - A). However, the possible effects on fish should generally be small, despite the relatively high frequency. In case of crayfish, the effect may be greater (even large), however, due to the small number of crayfish breeding farms, the frequency, meaning event risk is probably low. At the same time, absence of good data suggests an average degree of certainty.

a25. The effect of *the species* on individual animal health or animal production, by having properties that are hazardous upon **contact**, is:

	very low
	low
X	medium
	high
	very high

aconf21.	Answer provided with a	low	medium **X**	high	level of confidence

acomm25. Comments:

A particularly aggressive species (Jimenez and Faulkes 2011 - P), demonstrating nocturnal activity, thus it can potentially cause losses and injuries to fish resting on the bottom. Particularly dangerous when co-occurring with carp, in case of which this species shares similar temperature and habitat requirements. Difficult to completely eliminate from such habitats. Assuming that the species is present in Poland, the frequency of such events - due to the usually high population size and large numbers in breeding ponds - can be relatively high and exceed 100 cases per 100,000 breeding animals per year. However, any harmful effects are small due to wound healing.

a26. The effect of *the species* on individual animal health or animal production, by hosting **pathogens or parasites** that are harmful to them, is:

	inapplicable
	very low
	low
	medium
	high
X	very high

aconf22.	Answer provided with a	low	medium	high **X**	level of confidence

acomm26.	Comments: This species can transmit viral diseases, including the virus causing a diseased called White Spot Syndrome Virus (WSSV), known as the most dangerous viral disease in crustaceans (Chang et al. 1998, Baumgartner et al. 2009 - P) and thus threaten native crayfish breeding. This disease is on the OIE list, just like the crayfish plague, in case of which this species is also a vector (Aquiloni et al. 2011, Kozubíková-Balcarová et al. 2013 - P). The red swamp crayfish is an intermediate carrier of parasitic flukes dangerous to vertebrate household animals, mainly dogs and cats (Huner 1988 - P).

A4d | Impact on the human domain

Questions from this module qualify the consequences of *the organism* on humans. It deals with human health, being defined as a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity (definition adopted from the World Health Organization).

a27. The effect of *the species* on human health through **parasitism** is:

X	inapplicable
	very low
	low
	medium
	high
	vert high

aconf23.	Answer provided with a	low	medium	high	level of confidence

acomm27.	Comments: The species is not a parasite.

a28. The effect of *the species* on human health, by having properties that are hazardous upon **contact**, is:

	very low
X	low
	medium
	high
	very high

aconf24.	Answer provided with a	low	medium	high **X**	level of confidence

acomm28.	Comments: The possibility of minor injuries by pinching carries the risk of bacterial infection to a much higher degree than in other crayfish species (Thune 1994 - P) due to the habitat preferences of the species (potentially highly bacteriologically contaminated habitats). However, the frequency of such events is difficult to assess and the impact on health is generally low.

a29. The effect of *the species* on human health, by hosting **pathogens or parasites** that are harmful to humans, is:

	inapplicable
	very low
	low
	medium
X	high
	very high

aconf25.	Answer provided with a	low	medium	high **X**	level of confidence

acomm29. Comments:

Infection with the bacterium *Vibrio mimicus* was found in *P. clarkii* (Thune et al. 1991 - P), which can cause gastroenteritis in humans when eating undercooked meat. This species is a host of the parasite of the *Paragonimus* genus (Phillips 2016 - P), for which human is the ultimate host. Flukes of this genus accumulate in the lungs causing a serious disease known as paragonimiasis (Lane et al. 2009 - P). These diseases are dangerous, yet curable, but they can cause permanent damage, e.g. to the lungs (in case of flukes).

A4e | Impact on other domains

Questions from this module qualify the consequences of *the species* on targets not considered in modules A4a-d.

a30. The effect of *the species* on causing damage to **infrastructure** is:

	very low
	low
	medium
X	high
	very high

aconf26.	Answer provided with a	low	medium	high **X**	level of confidence

acomm30. Comments:

This species drills deep burrows, forming entire systems in the bottom and banks of reservoirs and watercourses, with a total length of up to a dozen or so meters, with a maximum depth of 2 m (Correia and Ferreira 1995, Kouba et al. 2013 - P). In particular, it can seriously affect hydrotechnical constructions (e.g. dikes, embankments, earth dams, etc.) constructed from materials such as sand, soil, clay, etc. Large losses due to damaged dams and embankments were confirmed in places of current presence (Hobbs 1981). Its impact will be most likely frequent and strong in Poland.

A5a | Impact on ecosystem services

Questions from this module qualify the consequences of *the organism* on ecosystem services. Ecosystem services are classified according to the Common International Classification of Ecosystem Services, which also includes many examples (CICES Version 4.3). Note that the answers to these questions are not used in the calculation of the overall risk score (which deals with ecosystems in a different way), but can be considered when decisions are made about management of *the species*.

a31. The effect of *the species* on **provisioning services** is:

	significantly negative
X	moderately negative
	neutral
	moderately positive
	significantly positive

aconf27.	Answer provided with a	low	medium **X**	high	level of confidence

acomm31.	Comments:

In case of its presence in warm, shallow carp ponds of intensive breeding, this species can cause significant losses (as a result of food competition, predation, mutilation of individuals, damage to fish during catches and transport). Difficult to remove even when drying the ponds (Kouba et al. 2013 - P). The negative effect may also manifest in relation to wild fish obtained by fishing or angling.

a32. The effect of *the species* on **regulation and maintenance services** is:

X	significantly negative
	moderately negative
	neutral
	moderately positive
	significantly positive

aconf28.	Answer provided with a	low	medium	high **X**	level of confidence

acomm32.	Comments:

The species strongly affects the qualitative and quantitative structure of aquatic ecosystems (Holdich 2002, Gherardi and Lazzara 2006 - P), taking over the role of a key species. The species demonstrates an extremely large effect on the biomass of aquatic plants (Gutierrez-Yurita et al. 1998 - P) and other aquatic organisms (Twardochleb et al. 2013 - P), therefore it can seriously disturb the functioning of the ecosystem by eliminating or transforming the role of its key elements. It also affects the regulation of zoonoses by transferring pathogens and parasites.

a33. The effect of *the species* on **cultural services** is:

	significantly negative
X	moderately negative
	neutral
	moderately positive
	significantly positive

aconf29.	Answer provided with a	low	medium	high **X**	level of confidence

acomm33.	Comments:

An invasive species that crowds out native species, and it significantly differs from them due to its high ecological plasticity. This disrupts some conceptual cultural connections, shaped historically on the basis of the native species characteristics (e.g. popular schematic association with the principle: "crayfish are a sign of clean water", which is not true in case of red swamp crayfish.

A5b | Effect of climate change on the risk assessment of the negative impact of *the species*

Below, each of the Harmonia^{+PL} modules is revisited under the premise of the future climate. The proposed time horizon is the mid-21st century. We suggest taking into account the reports of the Intergovernmental Panel on Climate Change. Specifically, the expected changes in atmospheric variables listed in its 2013 report on the physical science basis may be used for this purpose. The global temperature is expected to rise by 1 to 2°C by 2046-2065.

Note that the answers to these questions are not used in the calculation of the overall risk score, but can be but can be considered when decisions are made about management of *the species*.

a34. INTRODUCTION – Due to climate change, the probability for *the species* to overcome geographical barriers and – if applicable – subsequent barriers of captivity or cultivation in Poland will:

	decrease significantly
	decrease moderately
	not change
X	increase moderately
	increase significantly

aconf30.	Answer provided with a	low	medium	high **X**	level of confidence

acomm34. Comments:

Due to the key role of temperature in the broadly understood propagation of the species, it should be assumed that the increase in the probability of overcoming barriers is positively correlated with the warming degree. With the assumed temperature increase in 2046-2065 of 1-2°C, a moderate increase in the likelihood of introducing this species should be assumed. It seems that currently prevailing climatic conditions are rather suboptimal, and therefore warming will bring them closer to the optimum for *P. clarkii*. The analysis of the situation in Spain suggests that the species may reduce its range along with climate warming (Capinha et al. 2012 - P), however, the studies concern much warmer climate.

a35. ESTABLISHMENT – Due to climate change, the probability for *the species* to overcome barriers that have prevented its survival and reproduction in Poland will:

	decrease significantly
	decrease moderately
	not change
X	increase moderately
	increase significantly

aconf31.	Answer provided with a	low	medium	high **X**	level of confidence

acomm35. Comments:

Due to the key role of temperature in the broadly understood ecological buoyancy of the species, it should be assumed that the increase in the probability of establishment is positively correlated with the warming degree. With the assumed temperature increase between 2046 and 2065 of 1-2°C, it should therefore be assumed that there will be a moderate increase in the probability of this species' establishment.

a36. SPREAD – Due to climate change, the probability for *the species* to overcome barriers that have prevented its spread in Poland will:

	decrease significantly
	decrease moderately
	not change
X	increase moderately
	increase significantly

aconf32.	Answer provided with a	low	medium	high **X**	level of confidence

acomm36. Comments:

Due to the key role of temperature in the broadly understood propagation of the species, it should be assumed that the increase in the probability of spreading is positively correlated with the degree of warming. With the assumed temperature increase in 2046-2065 of 1-2° C, a moderate increase in the probability of spread should therefore be assumed. In addition, it is necessary to assume increasing interest in the breeding of this species, contributing to the anthropogenic translocation of the species throughout the country.

a37. IMPACT ON THE ENVIRONMENTAL DOMAIN – Due to climate change, the consequences of *the species* on wild animals and plants, habitats and ecosystems in Poland will:

	decrease significantly
	decrease moderately
	not change
X	increase moderately
	increase significantly

aconf33.	Answer provided with a	low	medium	high **X**	level of confidence

acomm37. Comments:

Due to the key role of temperature in shaping the metabolism and reproduction rate of the species, it should be assumed that the increased probability of the intensity concerning this species population's effect on the natural environment is positively correlated with the warming degree. With the assumed temperature increase in 2046-2065 of 1-2 °C, a moderate increase in the risk posed by this species should be assumed.

a38. IMPACT ON THE CULTIVATED PLANTS DOMAIN – Due to climate change, the consequences of *the species* on cultivated plants and plant domain in Poland will:

	decrease significantly
	decrease moderately
X	not change
	increase moderately
	increase significantly

aconf34.	Answer provided with a	low	medium **X**	high	level of confidence

acomm38. Comments:

Unless climate warming may justify the cultivation of rice, one should not expect changes in the impact of this species on plant production.

a39. IMPACT ON THE DOMESTICATED ANIMALS DOMAIN – Due to climate change, the consequences of *the species* on domesticated animals and animal production in Poland will:

	decrease significantly
	decrease moderately
	not change
X	increase moderately
	increase significantly

aconf35.	Answer provided with a	low	medium	high **X**	level of confidence

acomm39. Comments:

Due to the moderate increase in the establishment and spread of the species in relation to the expected temperature rise, an adequate increase in the negative impact of this species on aquaculture animal farms should be expected.

a40. IMPACT ON THE HUMAN DOMAIN – Due to climate change, the consequences of *the species* on human in Poland will:

	decrease significantly
	decrease moderately
	not change
X	increase moderately
	increase significantly

aconf36.	Answer provided with a	low	medium	high **X**	level of confidence

acomm40. Comments:

Due to the moderate increase in the establishment and spread of the species due to the expected temperature rise, one should expect an adequate increase in the risk to human health associated with increased probability of gastrointestinal infections, flukes, and bacteria transmitted by crayfish. Such a situation may occur in case of amateur crayfish catching for culinary purposes.

a41. IMPACT ON OTHER DOMAINS – Due to climate change, the consequences of *the species* on other domains in Poland will:

	decrease significantly
	decrease moderately
	not change
X	increase moderately
	increase significantly

aconf37.	Answer provided with a	low	medium	high **X**	level of confidence

acomm41. Comments:

When reaching the climatic optimum of the species, it is possible that its mass occurrences will show proportionally negative effect on the ground hydrotechnical constructions, shore strengthening, etc.

Summary

Module	Score	Confidence
Introduction (questions: a06-a08)	0.83	1.00
Establishment (questions: a09-a10)	0.75	1.00
Spread (questions: a11-a12)	0.75	0.75
Environmental impact (questions: a13-a18)	0.83	0.92
Cultivated plants impact (questions: a19-a23)	0.00	0.83
Domesticated animals impact (questions: a24-a26)	0.58	0.67
Human impact (questions: a27-a29)	0.50	1.00
Other impact (questions: a30)	0.75	1.00
Invasion (questions: a06-a12)	0.78	0.92
Impact (questions: a13-a30)	0.83	0.87
Overall risk score	0.65	
Category of invasiveness	very invasive alien species	

A6 | Comments

This assessment is based on information available at the time of its completion. It has to be taken into account. However, that biological invasions are, by definition, very dynamic and unpredictable. This unpredictability includes assessing the consequences of introductions of new alien species and detecting their negative impact. As a result, the assessment of the species may change in time. For this reason it is recommended that it regularly repeated.

acomm42.	Comments: In terms of the freshwater crayfish species, *Procambarus clarkii* is considered to be the most dangerous invasive species (Tricarico et al. 2010 - P). According to (Patoka et al. 2014 - P) with this regard, it is second after marbled crayfish *Procambarus fallax virginalis.* In Poland, this species is so far only reported in aquarium breeding (Strużyński 2007 - P, Bonk i Solarz 2017 - A) or as a food product, yet in the form of dead individuals (Strużyński 2007 - P). However, due to its popularity in amateur breeding, it can spread into open waters. It is a thermophilic species, which is why at least in the first stages of the invasion it should be expected mainly in heated discharge waters of industrial plants, e.g. coal power plants. However, due to the high plasticity of the species, possible expansion and negative effect on native ecosystems can be large. Having considered the foregoing, the current assessment of its invasiveness may be underestimated. The species has been recorded once in open waters in Poland. However, as the observer points out (Urbaniak 2014 - A), it was probably the effect of a one-time release by an aquarist.

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