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 assessor(s):

first name and family name

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

acomm01. Comments:

	degree	affiliation	assessment date
(1)	dr hab.	Institute of Nature Conservation of the Polish Academy of Sciences in Cracow	31-01-2018
(2)	mgr	Institute of Nature Conservation of the Polish Academy of Sciences in Cracow	23-01-2018
(3)	dr	Institute of Nature Conservation of the Polish Academy of Sciences in Cracow	31-01-2018

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

Polish name: Rak marmurkowy

Latin name: ***Procambarus fallax* f. *virginalis*** (Hagen, 1870)

English name: Marbled 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:

From 2010, the species was identified as *Procambarus fallax* f. *virginalis*, a parthenogenetic form of *Procambarus fallax*. Currently, based on the genetic differences and reproductive isolation in relation to *Procambarus fallax*, it was identified as a separate species *Procambarus virginalis* sp. nov. The site of the natural occurrence of the species, the so-called *locus typicus* remains unknown. Mentioned above species names are not synonymous. Using *P. fallax* as *P. virginalis* has now been considered as incorrect.

Polish name (synonym I)	Polish name (synonym II)
–	–
Latin name (synonym I)	Latin name (synonym II)
Procambarus virginalis sp. nov.	*Procambarus (Ortmannicus) fallax* f. virginensis
English name (synonym I)	English name (synonym II)
Marmorkrebs (*the German-language name used in English*)	–

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	high	level of confidence
		X	

acomm04. Comments:

In Poland, the species has been kept for many years in amateur aquariums. In our country, it has been available in trade and breeding since at least 2003 (Bonk 2003 – N). Very easy to breed and available at very low prices (approx. 3 PLN). In 2007 (Strużyński 2007 – P) it was already common in Polish aquaristics. It occurs in the open waters of Germany (e.g. Kouba et al. 2014 – P) or the Scandinavian Peninsula (Bohman et al. 2013 – P). In the area of the city of Szczecin, single individuals of this species were observed once in Jezioro Szmaragdowe lake and Jezioro Słoneczne pond (Śmietana 2009, 2010 – A).

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
	the human domain
X	the other domains

acomm05. Comments:

A very aggressive species, in this respect equal to red swamp crawfish (Jimenez and Faulkes 2011 – P), which, combined with the ability to rapidly increase its population size (through parthenogenesis, which theoretically enables a colonization of a new site in the case if only one individual is released to the environment), creates itself a serious hazard to the natural environment. There is no data on the impact of this species on aquatic vegetation and

	animals (fish) in open reservoirs, however observations of individuals kept in aquariums suggest a potentially very strong negative impact (Śmietana 2009, 2015 – A), which potentially poses a threat to the durability of ground hydrotechnical appliances. This species is a carrier of crayfish plague (Stayskall et al. 2013 – I, Keller et al. 2014 – P). Therefore, it can contribute to the disappearance of native crayfish, or cause losses in crayfish aquacultures.

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 **X**	high	level of confidence

acomm06.	Comments: Currently, the species has been found at 14 sites in Germany (including 5 permanent populations) and at one in Slovakia (Kozak et al. 2015 – P) and Ukraine (Novitsky and Son 2016 – P) while in 2006 it was registered only at one site in Germany (Carral et al. 2006). The occurrence in the countries bordering Poland (Bohman et al. 2013, Kouba et al. 2014 – P) suggests that a self-propelled expansion to Poland may take place. However, a mechanism of this propagation is unknown. Nevertheless, this suggests that a self-propelled expansion is possible, but unlikely, considering the current establishment outside the area of Poland.

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

	low
X	medium
	high

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

acomm07.	Comments: The probability for the species to be introduced by unintentional human actions is in this case a derivative of intentional actions. Reservoirs with a stable population can easily become a source of further, yet not fully intentional introductions. Considering a large population size and very small size of young marbled crayfish (aged 0+), it is very easy to transfer even a single individual (due to parthenogenesis, one specimen is sufficient to establish a population) with water or equipment used in the water of the reservoirs inhabited by this species. Although Polish anglers are very active abroad and considering the location of the nearest population of crayfish, it can be assumed that similar events should not happen more often than a few times 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:

All the authors of the studies describing the distribution of marbled crayfish in the world indicate that it is a result of intentional introductions being a consequence of ignorance or unawareness of people who perform them (e.g. Patoka et al. 2014 – P). In the case of Poland, it is similar and the probability of such an introduction approaches certainty. In addition to the two identified cases of the presence of marbled crayfish in reservoirs in the area of Szczecin, crayfish of this species offered as an undesired effect of the culture, were collected four times from different aquarists (Śmietana 2018 – A). Within the last 5 years, it was also seen on direct sale in a pet shop in Cracow (Bonk 2014 – N), and available for sale on the Internet, e.g. on Allegro website (Śmietana 2018 – A). Moreover, escapes from amateur breeding cannot be excluded, which also slightly increases the risk of expansion. It should be assumed that cases of the introduction of this species are frequent and may exceed 10 cases per decade.

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:

The site of the natural occurrence of the species remains unknown. Thus referring to native range becomes pointless. Therefore, because of the close relationship with *Procambarus fallax*, whose occurrence is known, it should be assumed that optimal climatic conditions are similar to those, which are found in the areas of its natural occurrence, or in the south-eastern US (states: Georgia and Florida) (Taylor et al. 2007 – P) (Taylor et al. This suggests a preference of marbled crayfish for higher ambient temperatures than those found in Poland. The optimal temperature for marbled crayfish is between 18 and 25°C (Kozak et al. 2015 – P). However, current distribution on of the species in Europe and the results of studies on tolerance to low temperatures (Veselý et al. 2015, Kaldre et al. 2016 – P) allow assuming that the occurrence of permanent populations of this species under climatic conditions of Central Europe, is possible.

a10. Poland provides **habitat** that is

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

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

acomm10. Comments:

In the areas of re-introduction, the species is observed both in flowing and standing waters. There are no data concerning relation of the species with water vegetation and nutrient amount. It can live in unstable reservoirs and survive drying (Hendrix and Loftus

2000, Dorn and Volin 2009 – P). It is able to establish in oxbow lakes and unstable anthropogenic reservoirs. Ecological plasticity of *P. fallax* (Carral et al. 2006 – P) allows for the assumption that marbled crayfish will find in Poland very favourable habitat conditions in all types of standing and flowing waters, especially those offering relatively high temperatures.

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
	medium
X	high
	very high

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

acomm11. Comments:

Assessment (Data type: C)
This species is ecologically flexible, therefore its spread with various types of water in water systems is possible. As the form of this species present in Europe is parthenogenetic (Martin et al. 2010, Buřič et al. 2011 – P) and was considered a new species (Lyko 2017 – P), as well as is characterized by high fertility and fast achievement of sexual maturity, even single individuals migrating to new waters may due to parthenogenesis become a serious problem and constitute a source of further invasion. It is worth noting that the species is also able to migrate overland and is relatively resistant to reservoir drying, which increases its chances of spreading (Chucholl et al. 2012 – P). It seems that establishment in new sites at a rate of more than 5 km per year is highly probable, especially in the case of watercourses.

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:

A popular species kept in aquariums. Breeding of this species quickly results in an excess of individuals, which favours introductions to natural reservoirs. Results of the analysis of the dispersal of this species in Europe (Carral et al. 2006 – P) and (Kouba et al. show the key role of humans in the expansion of the species and lead to the assumption of a similar situation in Poland. Therefore, both the release of the species to new areas, and the migration of the individuals over distances longer that 50 km from a population, which could establish in Poland, may occur with a much higher frequency than 10 cases 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
X	medium
	high

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

acomm13. Comments:

The fact is that up to date no population of marbled crayfish has been observed in natural conditions in Poland, except for single individuals at two sites, and no studies on its impact on these sites were conducted. However, the impact of this crayfish can be estimated based on observations under aquarium conditions, and the close relationship of *P. fallax* and *P. alleni* can be used. Both in one and the other point of view (or aquarium observations and analogy to related species), marbled crayfish potentially appears to be a key species, with a strong impact through predation or herbivory (e.g. VanArman 2011 – P). Therefore, it can affect species such as e.g. amur bitterling *Rhodeus sericeus* or European weatherfish *Misgurnus fossilis* (Annex II of the Habitat Directive), four leaf clover *Marsilea quadrifolia* (Polish Red Data Book of Plants 2014, EW category).

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:

Similarly to all species of American crayfish, marbled crayfish has a competitive advantage over native species of crayfish, in particular over European crayfish *Astacus astacus* (Polish Red Data Book of Animals, Krzywosz and Śmietana 2004 – P). It is associated with the "r" type of life strategy typical for the genus of *Procambarus* (large number of offspring, early maturation), and additionally with an ability to the parthenogenetic reproduction. It may probably compete for a shelter with native crayfish, because of its size, mainly with young individuals.

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:

Marbled crayfish does not interbreed with any species of crayfish, and even no hybrids with a related species *Procambarus fallax* (Lyko 2017 – P) were observed, despite the mating of these two species.

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:

Marbled crayfish is a confirmed vector of crayfish plague – the OIE list (Keller et al. 2015 – P), which makes it threaten in particular European crayfish *Astacus astacus*, for which this disease is lethal (Polish Red Data Book of Animals, VU category, Krzywosz and Śmietana 2004 – P, The IUCN Red List, VU category).

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 **X**	medium	high	level of confidence

acomm17. Comments:

It is a species digging burrows. In Poland, by changing the structure of banks, it may play a key role e.g.in the case of oxbow lakes (protected by the Community Law) classified as habitat 3150 – natural eutrophic lakes with *Magnopotamion* or *Hydrocharition*-type vegetation or other aquatic habitats through disintegration of banks, increase in water turbidity due to digging burrows.

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 **X**	high	level of confidence

acomm18. Comments:

On the basis of aquarium observations and systematic relationship with the genera of *Procambarus alleni* and *P. fallax*, it should be assumed that pathenogenetically reproducing marbled crayfish is able to completely rebuild a trophic network, both through its impact on vegetation, and detritus (VanArman 2011 – P), becoming the key species. Considering, among others, this potential, marbled crayfish has been recognized as the most dangerous species available on the aquarium species market in the Czech Republic; (Patoka et al. 2014

– P). Similar species also play a key role in aquatic ecosystems because of a negative, reductive effect on plants by feeding on them (VanArman 2011 – P). In Poland, it may have a key role in the case of habitats 3260 – water courses of plain to montane levels with the *Ranunculion fluitantis* vegetation and 3150 – natural eutrophic lakes with *Magnopotamion* or *Hydrocharition*-type vegetation.

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: No data. The probability of such an impact is relatively low.

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.

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

acomm20.	Comments: The species is an animal.

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	high **X**	level of confidence

acomm22.	Comments: Only indirect effect is possible because of the occurrence of changes in hydrographic conditions, caused by digging burrows in the embankments of watercourses and reservoirs.

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: Plant pathogens transmitted by this species are not known.

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
	low
X	medium
	high
	very high

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

acomm24.	Comments: The species is aggressive against other species of crayfish, gaining advantage in the case of direct clashes (Jimenez and Faulkes 2011 – P). Aquarium observations demonstrated huge aggression against fish. Attacks of marbled crayfish in aquariums, against individuals resting at night at the bottom resulted in injury in larger individuals and death of smaller ones; the latter were eaten (Śmietana 2015 – A). Under breeding conditions, it can potentially cause some losses on fish farms. However, because of the breeding characteristics dominant in

	the native carp aquaculture (growing juvenile fish in ponds, previously dried in special way), such events will be rather rare and including other farm animals (e.g. crayfish), they should not exceed 100 cases per 100000 animals, while the effect may sometimes be significant.

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
	medium
X	high
	very high

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

acomm25. Comments:

The species is aggressive against other species of crayfish, gaining advantage in the case of direct clashes (Jimenez and Faulkes 2011 – P). An aquarium observation demonstrated huge aggression against fish. Attacks of marbled crayfish against individuals resting at night at the bottom resulted in injury in larger individuals and death of smaller ones (Śmietana 2015 – A). The species may directly affect the cultures of native crayfish. It is anticipated that the frequency of such situations will be medium resulting in (at least sometimes) large effects.

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:

It is a confirmed carrier of crayfish plague *Aphanomyces astacii*, which is generally lethal to native crayfish (e.g. Keller et al. and a potential one of a viral disease of crustaceans WSS (White Spot Syndrome) (Mrugała et al. 2014 – P). Both diseases are included in the OIE list.

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:

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

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

acomm28. Comments:

There is a hazard of injury because of pinching, especially by large individuals (approx. 13 cm of total body length). However, the vast majority of individuals do not grow up to 10 cm in length, and the fact that females of crayfish (and thus all the individuals of marbled crayfish) have significantly smaller chelae than males in most species of crayfish, in addition significantly reduces the scale of this type of hazard. The effect of such injuries is generally small, and the frequency of events low.

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

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

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

acomm29. Comments:

There are no known pathogens and parasites, which could be transmitted by the species and which could be harmful to humans. A possible infection may occur in the case of human injury caused by crayfish. However, pathogens causing possible infections are not specific to marbled crayfish.

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

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

acomm30.	Comments: A real threat of this type can only be expected in the case of establishment of very large populations of marbled crayfish. Because of relatively shallow burrows dug by this species, the level of hazard related to causing more serious damage to dams or embankments should be considered relatively low. However, the frequency of such events will probably be low, and the effects reversible.

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	high **X**	level of confidence

acomm31.	Comments: Potentially, it may pose a direct threat to the occurrence of native species of crayfish and, being an aggressive species and a predator for fish, it may have a negative impact on the production size in aquaculture, especially in the case of thermophilic species in pond cultures.

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

	significantly negative
X	moderately negative
	neutral
	moderately positive
	significantly positive

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

acomm32.	Comments: Based on the analyses of marbled crayfish under aquarium conditions and considering the close relationship with *P. fallax* i *P. alleni*, a possibility of a significant effect of this species on regulation services in the case of the establishment of a locally numerous population, should be assumed. A possible effect could include the transformation of phytocenoses and quantitative and qualitative changes in the benthos, as well as the control of zoonotic diseases, as a result of their spread.

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:

European crayfish is a charismatic species, deeply embedded in Polish culture. For example, in the culture of speech (proverbs, sayings, comparisons), there are many references to the characteristics of European crayfish. The appearance of marbled crayfish in trade (aquaristics) and its availability, as well as the lack of features characteristic of European crayfish, causes in a so-called wide group of customers, a disturbed understanding of the cultural role and importance of crayfish, which understanding should be additionally associated with native crayfish as an important element of water.

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 **X**	high	level of confidence

acomm34. Comments:

The optimal temperature for marbled crayfish is between 18 and 25°C (Kozak et al. 2015 – P), which also means the optimal level of metabolism and thus motor skills. Considering the assumed temperature increase from 1 to 2°C in the years 2046-2065, a proportionally increased probability of effectively overcoming geographical barriers (if they exist), should be expected.

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 **X**	high	level of confidence

acomm35. Comments:

This species is able to survive winters in the climate of Central Europe at a temperature below 5°C (Kaldre et al. 2012 – P). However, in the light of the optimal climatic requirements of this species, any increase in the average temperature in this region should

	be considered to favour overcoming the existing barriers in the colonization of new habitats. A related species *P. fallax* is most likely able to survive winter in Poland (Veselý et al. 2012 – P), however, it is definitely thermophilic and climate warming may increase its chances of survival, and therefore of 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 **X**	high	level of confidence

acomm36.	Comments: A related species *P. fallax* is most likely able to survive winter in Poland (Veselý et al. 2012 – P), however, it is definitely more thermophilic and climate warming may increase its chances of survival. Therefore, the same probably applies to marbled crayfish, derived from *P. fallax*. Temperature in winter period seems to be a classical "minimum" factor conditioning the spread of marbled crayfish. Thus, any temperature increase is proportionally beneficial for increasing the ability to overcome barriers.

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 **X**	high	level of confidence

acomm37.	Comments: Temperature in winter period seems to be a classical "minimum" factor conditioning the ecological resilience of the species. Therefore, any increase in temperature is proportionally favourable for this species in view of its pressure on habitats and biocenoses at the sites of its establishment.

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	high **X**	level of confidence

acomm38.	Comments: There are no cultivated plants, which this species could affect and probably the climate change will not alter this situation.

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 **X**	high	level of confidence

acomm39. Comments:

Conditions close to the optimal ones may cause greater reproduction, which may be a problem for fish farms, e.g. through damaging levees of ponds, competition for food, some degree of predation etc. A larger number of individuals of marble crayfish may also increase the risk of the introduction of the species to few cultures of other crayfish present in Poland. Such events may result in crayfish plague transmission into crayfish aquacultures.

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

	decrease significantly
	decrease moderately
X	not change
	increase moderately
	increase significantly

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

acomm40. Comments:

The impact of the temperature rise on this type of interaction due to its minimal intensity should be considered insignificant.

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 **X**	high	level of confidence

acomm41. Comments:

A moderate increase on other domains impact is expected because of the improvement of environmental conditions reflected in the anticipated increase in ecological capacity of habitats in relation to this species. Larger populations of marbled crayfish proportionally to their size will increase the hazard for dam and embankment tightness caused by digging burrows.

Summary

Module	Score	Confidence
Introduction (questions: a06-a08)	0.67	0.67
Establishment (questions: a09-a10)	0.75	0.75
Spread (questions: a11-a12)	0.88	0.75
Environmental impact (questions: a13-a18)	0.75	0.67
Cultivated plants impact (questions: a19-a23)	0.00	1.0
Domesticated animals impact (questions: a24-a26)	0.75	0.83
Human impact (questions: a27-a29)	0.00	1.0
Other impact (questions: a30)	0.25	0.5
Invasion (questions: a06-a12)	0.76	0.72
Impact (questions: a13-a30)	0.75	0.80
Overall risk score	0,57	
Category of invasiveness	moderately 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 is regularly repeated.

acomm42. Comments:

It is considered to be a dangerous and aggressive invasive species of crayfish (Jimenez and Faulkes 2010). The high level of invasiveness of this species and its unique genetic characteristic (all individuals are clones of one parent individual) were described in the study. This species is most probably a triploidal form of the species *P. fallax*. It is also a parthenogenetic form, which enables the invasion of new reservoirs by a release of only one individual. The species is popular in aquarium cultures. It was also found at two sites in Poland. The similarity to young individuals of spinycheek crayfish *Orconectes limosus* popular in Poland may cause that even during catches, this species could have been overlooked, therefore its occurrence on a larger scale is possible. Lyko (2017) has recently raised doubts regarding this species, recognizing marble crayfish occurring in Europe and commercially available a different species than *Procambarus fallax*, namely *P. virginalis* sp. nov. In view of this study it is possible that some of the predictions included in the present questionnaire may cease to be true. However, the ecology of this newly described species is unknown, therefore it was assumed that the reference to *P. fallax* is as yet a suitable approach to predict the effect of marbled crayfish on native ecosystems and human activity.

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