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. Anna Maria Łabęcka – external expert
2. Aneta Spyra
3. Małgorzata Strzelec

acomm01. Comments:

	degree	affiliation	assessment date
(1)	dr	Institute of Environmental Sciences, Faculty of Biology, Jagiellonian University in Cracow	11-01-2018
(2)	dr	Department of Hydrobiology, Faculty of Biology and Environmental Protection, University of Silesia	31-01-2018
(3)	prof. dr hab.	Department of Hydrobiology, Faculty of Biology and Environmental Protection, University of Silesia	01-02-2018

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

Polish name: –

Latin name: ***Corbicula fluminalis*** (O.F. Müller, 1774)

English name: Asiatic clam

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: none

Latin names and synonyms according to The IUCN Red List of Threatened Species (B) and Kołodziejczyk and Łabęcka (2011 – P).

The taxonomic status of *C. fluminalis* is unclear (Skuza et al. 2009 – P), since there is no clear answer to the question whether it is a separate species or morphological form of *Corbicula fluminea* only, and it might even be a complex of clonal androgenetic lines. According to guides for the identification of molluscs in Europe, it is different species than *C. fluminea* (Glöer and Meier-Brook 1998 Piechocki and Wawrzyniak-Wydrowska 2016 – P), but only Piechocki and Wawrzyniak-Wydrowska (2016 – P) took into account the data on the molecular and evolutionary biology of these species, and indicate that *C. fluminalis* can form hybrids with *C. fluminea* (Pfenniger et al. 2002 – P). The formation of such hybrids is based on androgenetic reproduction associated with the so-called sperm parasitism in oocyte, including the removal of genetic material of the oocyte nucleus (Hedtke et al. 2008, Pigneur et al. 2011 – P).

Polish name (synonym I)	Polish name (synonym II)
–	–
Latin name (synonym I)	Latin name (synonym II)
Corbicula fluminea	*Corbicula japonica*
English name (synonym I)	English name (synonym II)
Asian clam	–

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
	alien, present in Poland in the environment, not established
X	alien, present in Poland in the environment, established

aconf01. Answer provided with a

low	medium	high
	X	

level of confidence

acomm04. Comments:

Corbicula fluminalis is present in Poland. The presence of this species was first recorded in the lower course of the Oder River, in the cooling water discharge canal of the "Dolna Odra" power plant (West Pomeranian Voivodeship) (Łabęcka et al.) 2005 – P). This clam was also found in the Oder River at its section in Głogów (Piechocki and Szlauer-Łukaszewska 2013 – P). It is sparse, yet it reproduces – its reproductive cycle is known only in the heated cooling waters of the open canal at the "Dolna Odra" power plant (Łabęcka 2009 – P). There is no data on reproduction at the site of near Głogów.

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

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

acomm05.	Comments:

The effect of the species on basic environmental domains is unknown both in Poland and around the world. The *C. fluminalis* and *C. fluminea* clams hybridize with each other, which is why one can only assume that the influence of *C. fluminalis* could be similar to the influence of *C. fluminea*, but provided that numerous and large populations were created, which has not been observed in Poland so far. In Europe, *C. fluminalis* forms sympatric populations with *C. fluminea*, but is scarcer – its share is estimated at approx. 10% of individuals in Corbicula assemblages (Piechocki and Wawrzyniak-Wydrowska 2016 – P). The effect on different spheres (domains) based on negligible literature data was described in answers to questions a13-a18, a28-a29, a30-a33.

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
	medium
X	high

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

acomm06.	Comments:

There is no data on the self-propelled expansion of *C. fluminalis*, but this species is already present and establish in Poland. According to the Harmonia^{+PL} methodology – the procedure for negative impact risk assessment for invasive alien species and potentially invasive alien species in Poland (hereinafter Harmonia^{+PL}) the selection of an answer is indicated: high probability, with a high level of confidence.

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:

The species is already present in Poland and is regarded as established, but the way of introducing *C. fluminalis* to Polish inland waters is unknown. According to the Harmonia^{+PL} methodology the selection of following answer is indicated: high probability, with a high level of confidence.

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 already present in Poland and is regarded as established. There is no literature data on the intentional introduction of this species to waters. According to the Harmonia^{+PL} methodology the selection of the following answer is indicated: high probability, with a high level of confidence.

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

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

acomm09. Comments:

The species originated from Asia. The natural area of presence for *C. fluminalis* includes Iran, Lebanon, Israel, Afghanistan, south-eastern Anatolia, Kashmir, India, China, Middle East, Transcaucasia (Kołodziejczyk and Łabęcka 2011 – P). According to Morton (1982 – P) *C. fluminalis* is a thermophilic species, so because of that, it seems that the climatic conditions in Poland cannot be considered as optimal for the establishment of this species. So far only two sites of occurrence of *C. fluminalis* in Poland have been recorded (Łabęcka et al. 2005, Piechocki and Szlauer-Łukaszewska 2013 – P), but the reproduction of these clams is confirmed only for a habitat located in warm cooling waters. According to the Harmonia^{+PL} methodology the selection of following answer is indicated: high probability, with a high level of confidence.

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:

Corbicula fluminalis inhabits rivers and lakes, but prefers lentic water and slow water flow; it is typical for brackish estuaries (Morton 1982, Park and Kim 2003, Korniushin 2004, Skuza et al. 2009 – P). It is also found in the same habitats as *C. fluminea*, but always in a low number (Paunović in. 2007 – P). Also in Poland, *C. fluminalis* forms sympatric populations with *C. fluminea* and has so far only been recorded in two places (Łabęcka et al. 2005, Piechocki and Szlauer-Łukaszewska 2013 – P). It is found on the sandy, sandy-muddy bottoms (Skuza et al. 2009 – P), it can also inhabit stony and cobblestone substrates (Ciutti and Cappelletti 2009 – P). It is characterized by a lower growth rate compared to *C. fluminea* and greater sensitivity to freezing and low temperatures (Mouthon and Parghentanian 2004 – P), therefore it shall be assumed that this species will not form permanent and large populations in Poland. A density of 40-80 individuals/m^2 (Łabęcka 2005-2007 – A) is recorded in the cooling waters of the lower Oder River. Habitat conditions

	in Poland can not be described as optimal for the establishment of *C. fluminalis* due to insufficient salinity of inland waters, but according to the Harmonia[+PL] methodology the selection of following answer is indicated: high probability, with a high level of confidence.

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
	high
X	very high

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

acomm11. Comments:

Dispersion from a single source (Data type: A) (over 50 km per year). No data for Poland. It should be assumed that due to the hybridization with *C. fluminea*, *C. fluminalis*, like *C. fluminea*, can cover large distances, mainly passively as a larva carried with water current, and with animal involvement (Prezant and Chalermat 1984, Bij de Vaate 1991, McMahon 2000, 2002, Cantanhede et al. 2008 – P). Nevertheless, climatic conditions can be a limiting factor for the survival of larvae.

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

X	low
	medium
	high

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

acomm12. Comments:

There is no data on human participation in the spread of *C. fluminalis*. The species was found to date in Poland in two sites (Łabęcka et al. 2005, Piechocki and Szlauer-Łukaszewska 2013 – P). Assuming, according to the Harmonia[+PL] methodology, that the species occurs throughout Poland, it seemed that the frequency of individuals or diaspores movement or on a distance greater than 50 km is small. According to the Harmonia[+PL] methodology, this means that no more than 1 case per decade is expected.

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
X	low
	medium
	high

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

acomm13. Comments:

Corbicula fluminalis does not affect native species through predation, parasitism or herbivorousness. This species is a filter feeder, and its diet may include phytoplankton.

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

	low
	medium
X	high

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

acomm14. Comments:

No data. Due to the significant similarity to *C. fluminea* in the aspect of occupied habitats and nutrition, it can be assumed that at high densities, the influence of *C. fluminalis* could be similar to *C. fluminea* in terms of reduciton of suitable habitats and displacement of native bivalves. However, according to studies by Rajagopal et al. (2000 – P), this species increases its biomass in the period from December to March, when the availability of chlorophyll "a" is small, indicating the use of an alternative food source (bacterioplankton and detritus). Theoretically, due to formation of hybrids with *C. fluminea*, it can be assumed that *C. fluminalis* can play the same role in the natural environment as *C. fluminea*. However, *C. fluminalis* occurs rarely and in low numbers. Assuming that the species will spread throughout the country, it will be able to cause serious decreases in the population size of native special care species (e.g bivalves).

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:

Corbicula fluminalis does not interbreed with native bivalve species, but it forms hybrids with invasive *C. flumin*ea (Pfenniger et al. 2002 – P).

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

X	very low
	low
	medium
	high
	very high

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

acomm16. Comments:

No internal parasites harmful to native species were found in *Corbicula fluminalis* (Łabęcka 2009 – P, Riccardi 2016 – I).

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

X	low
	medium
	high

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

acomm17. Comments:

No data. At the moment, the effect of *C. fluminalis* is assessed as "small" due to the rarity of the described species in Poland. There is no data on this type of effect, therefore it is impossible to fully predict the consequences of its possible future presence. It is known, however, that this species demonstrates high ability to accumulate heavy metals (Al-Jaberi 2015 – P). Theoretically, due to the formation of hybrids with *C. fluminea*, it can be assumed that *C. fluminalis* can play the same role in the natural environment as *C. fluminea*. Assuming that the species will spread throughout the area of the entire country, its impact on the ecosystem integrity by disturbing abiotic factors could be assessed as "low". According to the Harmonia^{PL+} methodology, in the worst case, the species will cause easily reversible changes in processes occurring in habitats that do not belong to habitats of special care.

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

	low
X	medium
	high

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

acomm18. Comments:

Corbicula fluminalis is a good source of certain fatty acids, and it plays an important role in the food chain as food for fish, water birds, and mammals (Ekin et al. 2012 – P) (positive effect). There is no other data on the effect of the species on the integrity of the ecosystem through interference with its biotic factors. Due to the limited occurrence of *C. fluminalis* in Poland, the effect of this species on the integrity of the ecosystem by disrupting its biotic factors is assessed as low, yet assuming its spread throughout Poland, its effect should be considered as medium. In the worst case scenario, the species will cause hardly reversible changes in processes occurring in habitats that do not belong to special care habitats or it may cause easily reversible changes in the special care habitats.

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: *Corbicula fluminalis* lives in water. It is a filtrating clam, therefore it does not affect plant cultivation through herbivorousness or parasitism.

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: Clams are water animals. They do not compete with cultivated plants.

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: Clams are animals.

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: *Corbicula fluminalis* does not affect the cultivation of plants by disturbing their integrity.

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 is no data that would indicate that *C. fluminalis* could be a host or vector for pathogens and parasites that are harmful to plants.

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
X	very low
	low
	medium
	high
	very high

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

acomm24.	Comments: *Corbicula fluminalis* does not affect the health of a single animal or animal production through predation or parasitism.

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

X	very low
	low
	medium
	high
	very high

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

acomm25.	Comments: There is no data that would indicate that these clams could have an effect on the health of an individual animal or animal production by presenting properties that pose a danger during direct contact.

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
X	very low
	low
	medium
	high
	very high

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

acomm26.	Comments: There is no data that would say that *C. fluminalis* is a vector of parasites to farm and pet animals.

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: Similar to other species of bivalves, the species is a filtering clam and does not lead to a parasitic lifestyle.

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: Bivalve tissues secrete mucus which can be allergenic for some people as a result of direct contact (BHP UJ 2010 – I). The probability of *C. fluminalis* effect on human health is low (less

	than one case of contact per 100,000 people per year), with small effect (medical consultations are rare, the disease does not cause absenteeism, there are no permanent disabilities, low stress level).

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: In the area of native range, *C. fluminalis*, it is one of edible clams. Transmission of parasites by this species has not been demonstrated.

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 **X**	medium	high	level of confidence

acomm30.	Comments: No harmful effect of *C. fluminalis* on hydrotechnical devices or contamination of commercially offered gravel or sand with clam shells has been demonstrated in Poland and around the world. Despite the extremely high *C. fluminea* effect recorded in the USA, Belgium and France (Lachner et al. 1970, Swinnen et al. 1998, Darrigran 2002 – P), *C. fluminalis* does achieve densities as high as *C. fluminea*. It occurs sympatrically with *C. fluminea*, yet its share in the population is estimated at around 10% (Piechocki and Wawrzyniak-Wydrowska 2016 – P). One can only suspect that at high densities, *C. fluminalis* could cause some difficulties with regard to infrastructure, but so far there is no such data. This effect should not be as high as in case of *C. fluminea*, as the described species occurs less frequently (Kołodziejczyk and Łabęcka 2011 – P). The effect of the described species on the infrastructure seems to be insignificant at the moment, and with possible establishment in the entire country – low (average probability: over 1, but no more than 100 events per 100,000 objects per year, minor effect: completely 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 **X**	medium	high	level of confidence

acomm31. Comments:

There is no data for Poland and other countries. One can only suspect that at high densities *C. fluminalis* could, for example, cause clogging of hydrotechnical devices. However, this effect should not be as high as in case of *C. fluminea*, because the proportion of *C. fluminalis* in the sympatric populations is estimated at 10%. The effect of the described species on the infrastructure seems to be irrelevant at the moment, and with possible establishment in the entire country – moderately negative.

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 **X**	medium	high	level of confidence

acomm32. Comments:

No detailed data for Poland and other countries. All we know is, clams – when filtering water – can accumulate protozoa that are dangerous for humans, e.g. from the *Cryptosporidium* genus (Izumi et al. 2004 – P). Such protozoa may be present in water contaminated with feces. Theoretically, due to formation of hybrids with *C. fluminea*, it can be assumed that *C. fluminalis* could play the same role in the environment as *C. fluminea*. Assuming that the species will spread around the area of Poland, its effect on regulatory services will be moderately negative, due to the fact that, similar to *C. fluminea*, it may, for example, transform habitats, absorb larvae and sperms of native species of bivalves, as well as compete for food and habitat.

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

	significantly negative
	moderately negative
X	neutral
	moderately positive
	significantly positive

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

acomm33. Comments:

There is no data that would indicate that this clam influences cultural services in our country.

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
X	not change
	increase moderately
	increase significantly

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

acomm34. Comments:

The probability that due to global warming the species would be introduced more often will not change.

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:

Corbicula fluminalis reproduces in Poland, yet its reproductive cycle is known only for the population of clams living in warm cooling waters (Łabęcka 2009 – P). The observed tendency of climate change leading to its warming may result in *C. fluminalis* clams will reproducing outside the cooling waters, and forming stable populations there.

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: There is little data on the biology and ecology of this species (if it is a separate species and not the a *C. fluminea* form), which could be taken into account when assessing the probability of its spread due to climate change. It seems that along with the increasing temperature of the water, *C. fluminalis* could reproduce outside the cooling waters and its reproductive cycle could be shortened and repeated several times during the year. It is possible that the survival of spontaneously disseminated *C. fluminalis* larvae in warmer waters will increase. According to Morton (1982 – P), *C. fluminalis* is thermophilic, which is why climate change towards warming of waters can favor the spread into new areas by these clams.

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 **X**	medium	high	level of confidence

acomm37.	Comments: The probability is difficult to determine, due to absence of data on the harmful effects of *C. fluminalis* on natural habitats and other animals. As a result of climate change, clams will probably reproduce more frequently or (and) their reproductive cycle will be shortened. Larval survival may also increase, which in turn could lead to an increase in the population size. There may be a strong competition with native species for resources (food, living space).

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: The species is an aquatic animal and does not affect arable crops or plant production in Poland. It is unlikely that this situation will change as a result of climate change.

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
X	not change
	increase moderately
	increase significantly

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

acomm39.	Comments: The species does not affect animal husbandry. It is unlikely that this situation will change as a result of climate change.

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 **X**	high	level of confidence

acomm40.	Comments: There is no data on the effect of this species on humans, therefore it is unlikely that this effect would change as a result of climate change.

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: So far, no effect of this species on other objects has been found. In case of global warming it can be assumed that the species will form more populations and its effect is likely to increase. Climate warming could result in, e.g. more frequent reproduction, and lead to an increase in the population number, as well as colonization of a larger area. As a consequence, *C. fluminalis* could become an undesirable species in water reservoirs and clog up hydrotechnical devices, water pipes.

Summary

Module	Score	Confidence
Introduction (questions: a06-a08)	1.00	1.00
Establishment (questions: a09-a10)	1.00	1.00
Spread (questions: a11-a12)	0.50	0.50
Environmental impact (questions: a13-a18)	0.25	0.58
Cultivated plants impact (questions: a19-a23)	0.00	1.00
Domesticated animals impact (questions: a24-a26)	0.00	1.00
Human impact (questions: a27-a29)	0.00	1.00
Other impact (questions: a30)	0.25	0.00

Invasion (questions: a06-a12)	0.83	0.83
Impact (questions: a13-a30)	0.25	0.72
Overall risk score	0.21	
Category of invasiveness	non-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:

Corbicula fluminalis was found in Poland in two sites, and it was probably introduced into our national waters together with the transport of fish as a plankton larva present in the water. Around the world, the species is also known for its ability to get into new habitats attached to the vessel hulls (Hubenov 2001 – P). Environmental changes in the form of waterway modification may favor the spread of this clam. It plays a role in trophic chains as food for fish, birds, mammals and amphibians in water environments where it occurs (Ekin et al. 2012 – P). The taxonomic status of *C. fluminalis* is unclear (Skuza et al. 2009 – P), and it is assumed that different *Corbicula* lines may be considered as the initial stage for a group of species (Kołodziejczyk and Łabęcka 2011 – P). This clam coexists with *C. fluminea* with which it forms androgenetic hybrids (Pfenniger et al. 2002, Domagała et al. 2004, Hedtke 2008, Pigneur et al. 2011 – P). Due to this phenomenon, it can be assumed that the *C. fluminalis* effect on the natural environment is the same or similar to *C. fluminea* (a13-a18, the result of the questionnaire 0.25). The number of *C. fluminalis* individuals in sympatric populations is lower compared to *C. fluminea*, therefore the *C. fluminalis* effect on other objects (question a30, survey result 0.25), invasion process (question a06-a12, questionnaire result 0.83) and the negative impact (a13-a30, questionnaire result 0.25) was rated as smaller compared to the result of the questionnaire for *C. fluminea*. *Corbicula fluminalis* is most often dioecious (Morton 1982, Rajagopal et al. 2000 – P), yet only hermaphrodites were found in Poland (Łabęcka 2009 – P). Morton (1982 – P) believes that hermaphroditism can ensure the survival of these clam populations in adverse or unstable environmental conditions. The questionnaire result for establishment (a09-a10) is 1.00, which means that the species is established and in accordance with the Harmony^{PL+} methodology it is assumed that the climate and habitat conditions are optimal for this species. Overall risk score: 0.21 is also largely due to the lack of studies on *C. fluminalis.* This clam inhabits the river estuaries and is resistant to salinity (Piscart et al. 2005 – P). It can be assumed that a small number of its sites of presence in Poland could be associated with insufficiently high water salinity. In case of this species, as well as *C. fluminea*, with which it may hybridize, it would important be to constantly monitor their establishment, and indicate any new sites of presence. It is also important to have the ability to distinguish between both clams and not to identify *C. fluminalis* as juvenile *C. fluminea* individuals by mistake.

Data sources

1. Published results of scientific research (P)

Al-Jaberi MH. 2015. Heavy metal concentrations in the bivalve *Corbicula fluminalis* shells from Shatt Al-Arab River. International Journal of Marine Science 5: 1-4

Bij de Vaate A. 1991. Colonization of the German part of the River Rhine by the Asiatic clam, *Corbicula fluminea* Müller, 1774 (Pelecypoda, Corbiculidae). Bulletin Zoölogisch Museum. Universiteit van Amsterdam 13(2): 13-16

Cantanhede G, Hahn NS, Gubiani ÉA, Fugi R. 2008. Invasive molluscs in the diet of *Pterodoras granulosus* (Valenciennes,1821) (Pisces, Doradidae) in the Upper Paraná River floodplain, Brazil. Ecol. Freshw. Fish. 17: 47-53

Ciutti F, Cappelletti C. 2009. First record of *Corbicula fluminalis* (Müller, 1774) in Lake Garda (Italy), living in sympatry with *Corbicula fluminea* (Müller, 1774) Journal of Limnology 68: 162-165

Darrigran G. 2002. Potential impact of filter-feeding invaders on temperate inland freshwater environments. Biological Invasions 4: 145-156

Domagała J, Łabęcka AM, Pilecka-Rapacz M,Migdalska B. 2004. *Corbicula fluminea* (O.F. Müller, 1774) (Bivalvia: Corbiculidae) – a species new to the Polish malacofauna. Folia malacologica 12 (3): 145-148

Ekin I, Başhan M,Şeşen R. 2012. Fatty acid composition of lipid classes in two mussel populations (*Anodonta piscinalis* and *Corbicula fluminalis*) living in Tigris River. Turkish Journal of Biochemistry 37: 196-203

Glöer P, Meier-Brook C. 1998. Süsswassermollusken. 136-136 Deutscher Jugendbund für Naturbeobachtung. Hamburg

Hedtke S, Stanger-Hall K, Baker RJ, Hillis DM. 2008. All-male asexuality: origin and maintenance of androgenesis in the asian clam *Corbicula*. Evolution 62-5: 1119-1136

Hubenov Z. 2001. Corbiculidae: a new family to the Bulgarian recent Malacofauna (Mollusca, Bivalvia). Acta Zoologica Bulgarica 53: 61-66

Izumi T, Itoh Y, Yagita K, Endo T, Ohyama T. 2004. Brackish water benthic shellfish (*Corbicula japonica*) as a biological indicator for *Cryptosporidium parvum* oocysts in river water Bull Environ Contam Toxicol. 72(1): 29-37

Kołodziejczyk A, Łabęcka AM. 2011. *Corbicula fluminalis*.In: Z Głowaciński, H Okarma, J Pawłowski, W Solarz (ed.). Gatunki obce w faunie Polski. 146-150 Instytut Ochrony Przyrody PAN, Kraków

Korniushin AV. 2004. A revision of some Asian and African freshwater clams assigned to *Corbicula fluminalis* (Müller, 1774) (Mollusca: Bivalvia: Corbiculidae), with review of anatomical characters and reproductive features based on museum collections. Hydrobiologia 529: 251-270

Lachner EA, Robins CR, Courtenay WR Jr. 1970. Exotic fishes and other aquatic organisms introduced into North America. Smithsonian Contributions to Zoology 59: 1-29

Łabęcka AM. 2009. Cykl płciowy zawleczonych gatunków małży *Sinanodonta woodiana* (Lea, 1834), *Corbicula fluminea* (O.F. Müller, 1774) oraz *Corbicula fluminalis* (O.F. Müller, 1774) (Mollusca: Bivalvia) z kanału zrzutowego wód pochłodniczych Elektrowni Dolna Odra. 1: 1-163 Rozprawa doktorska, Uniwersytet Szczeciński, Szczecin.

Łabęcka AM, Domagala J, Pilecka-Rapacz M. 2005. First record of *Corbicula fluminalis* (OF Muller, 1774)(Bivalvia: Corbiculidae) in Poland. Folia Malacologica 13: 25-27

McMahon RF. 2000. Invasive characteristics of the freshwater bivalve *Corbicula fluminea*.In: R Claudi, J Leach (eds.). Nonindigenous Freshwater Organisms: Vectors, Biology and Impacts. 315-343 Lewis Publishers, Boca Raton

McMahon RF. 2002. Evolutionary and physiological adaptations of aquatic invasive animals: r selection versus resistance. Can. J. Fish. Aquat. Sci. 59: 1235-1244

Morton B. 1982. Some aspects of the population structure and sexual strategy of *Corbicula* cf. *fluminalis* (Bivalvia: Corbiculacea) from the Pearl River, Peoples Republic of China. Journal of Molluscan Studies 48: 1-23

Mouthon J, Parghentanian T. 2004. Comparison of the life cycle and population dynamics of two *Corbicula* species, *C. fluminea* and *C. fluminalis* (Bivalvia: Corbiculidae) in two French canals. Archiv für Hydrobiologie 161 (2): 267-287

Park JK, Kim W. 2003. Two *Corbicula* (Corbiculidae: Bivalvia) mitochondrial lineages are widely distributed in Asian freshwater environment. Molecular Phylogenetics and Evolution 29: 529-539

Paunović M, Csányi B, Knežević S, Simić V, Nenadić D, Jakovčev-Todorović D, Bojana Stojanović, Cakić P. 2007. Distribution of Asian clams *Corbicula fluminea* (Müller, 1774) and *C. fluminalis* (Müller, 1774) in Serbia. Aquatic Invasions 2: 99-106

Pfenninger M, Reinhardt F, Streit B. 2002. Evidence for cryptic hybridization between different evolutionary lineages of the invasive clam genus *Corbicula* (Veneroida, Bivalvia). Journal of Evolutionary Biology 15: 818-829

Piechocki A, Szlauer-Łukaszewska A. 2013. Molluscs of the middle and lower Odra: the role of the river in the expansion of alien species in Poland. Folia Malacologica 21: 73-86

Piechocki A, Wawrzyniak-Wydrowska B. 2016. Guide to freshwater and marine Mollusca of Poland. 189-193 Bogucki Wydawnictwo Naukowe. Poznań

Pigneur LM, Marescaux J, Roland K, Etoundi E, Descy JP, Van Doninck K. 2011. Phylogeny and androgenesis in the invasive *Corbicula* clams (Bivalvia, Corbiculidae) in Western Europe. Evolutionary Biology 11: 147

Piscart C, Moreteau JC, Beisel JN. 2005. Biodiversity and structure of macroinvertebrate communities along a small permanent salinity gradient (Meurthe River, France). Hydrobiologia 551: 227-236

Prezant RS, Chalermwat K. 1984. Flotation of the bivalve *Corbicula fluminea* as a means of dispersal. Science 225: 1491-1493

Rajagopal S, Velde G, Vaate A. 2000. Reproductive biology of the Asiaticn clams *Corbicula fluminalis* and *Corbicula fluminea* in the river Rhine. Archiv für Hydrobiologie 149: 403-420

Skuza L, Łabęcka AM, Domagała J. 2009. Cytogenetic and morphological characterization of *Corbicula fluminalis* (O.F. Müller, 1774)(Bivalvia: Veneroida: Corbiculidae): taxonomic status assessment of a freshwater clam. Folia biologica (Kraków) 57: 177-185

Swinnen F, Leynen M, Sablon R, Duvivier L, Vanmaele R. 1998. The Asiatic clam Corbicula (Bivalvia: Corbiculidae) in Belgium. Bulletin de l'Instut Royal Des Scienses Naturelles de Belgique. Sciences de la Terre Biologie 68: 47-53.

2. Databases (B)

The IUCN. 2017. Red List of Threatened Species (http://www.iucnredlist.org/details/98201936/0) Access: 2018-01-26

3. Unpublished data (N)

–

4. Other (I)

BHP UJ. 2010. Zalecenia BHP Uniwersytetu Jagiellońskiego

Riccardi N. 2016. Informacja ustna podczas wystąpienia na Europejskim Kongresie Malakologicznym w Krakowie

5. Author's own data (A)

Łabęcka AM. 2005-2007. Badania własne nieopublikowane