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 Cieplok
2. Monika Normant-Saremba – external expert
3. Małgorzata Strzelec

acomm01. Comments:

	degree	affiliation	assessment date
(1)	dr	Department of Hydrobiology, Faculty of Biology and Environmental Protection, University of Silesia	30-01-2018
(2)	dr hab.	Department of Experimental Ecology of Marine Organisms, Institute of Oceanography, University of Gdansk	23-01-2018
(3)	prof. dr hab.	Department of Hydrobiology, Faculty of Biology and Environmental Protection, University of Silesia	02-02-2018

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

Polish name: Ostryga pacyficzna

Latin name: ***Crassostrea gigas*** (Thunberg, 1793)

English name: Pacific giant oyster

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) *Magallana gigas* (Thunberg, 1793)	Latin name (synonym II) –
English name (synonym I) Pacific oyster	English name (synonym II) –

a03. **Area** under assessment:

Poland

acomm03.	Comments: –

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

	native to Poland
X	alien, absent from Poland
	alien, present in Poland only in cultivation or captivity
	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 **X**	level of confidence

acomm04.	Comments: Pacific giant oyster was introduced to many countries in the world for farming purposes, as a substitute for native oyster species, affected by diseases, excessive exploitation or habitat loss (Wolff and Reise 2002, Diederich *et al.* 2005 – P). However, occurrence of this species has not been confirmed in Poland hitherto, similarly as in other countries of the Baltic Sea basin (AquaNIS Editorial Board 2015 – B).

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: Pacific giant oyster may affect the natural environment significantly, by its monopolisation, forming dense reefs in the coastal zone (Mortensen *et al.* 2017 – P). Occurring in high densities, the oyster competes with native bivalve species, both for place, and for food (Nehring 2011 – B, Herbert *et al.* 2016 – P). In many countries, uncontrolled natural reproduction of the Pacific giant oyster resulted in a significant increase in its population, leading in turn to a decrease in populations of native species (Diederich *et al.* 2005 – P). Also, the Pacific giant oyster may breed hybrids with other oyster species, endangering their populations (Huvet *et al.* 2004, Leitao *et al.* 2007 – P, DAISIE 2008 – B). Moreover, it is a carrier of various pathogens and parasites (Enriquez-Espinoza *et al.* 2010 – P, Nehring 2011 – B). The Pacific giant oyster is an engineering species, which transforms the environment, contributing, on one hand, into an increase in local biodiversity, and on the other hand, changing the physic-chemical parameters of water (Herbert *et al.* 2016 – P). It may lead to, both directly, and indirectly, disturbances in the functioning of the ecosystem (Dolmer *et al.* 2014 – I, Herbert *et al.* 2016 – P). Moreover, dense reefs of the Pacific giant oyster affect recreation values adversely, hindering the use of beaches. Hard and sharp shells of the species may pose a direct hazard for the human safety, injuring their skin or

damaging their shoes (Wolff and Reise 2002 – P, GISD 2015 – B). Besides, oysters, as filter feeders, have a high capability to accumulate contaminations in soft tissue, to high concentrations which may be dangerous for people eating clams (Quayle 1988, Guéguen *et al.* 2008 – P). The Pacific giant oyster is a species utilised in aquaculture, thus having a high economic significance (Cultured Aquatic Species Information Programme 2005 – B). It is one of two non-native invertebrates which may be farmed in the EU countries without permission (EC 2007 Regulations Council Regulation (EC) No 708/2007 of 11 June 2007 concerning use of alien and locally absent species in aquaculture – P).

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:

X	low
	medium
	high

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

acomm06. Comments:

Planktonic larvae of the Pacific giant oyster may be spread to long distances by sea currents (GISD 2015, Nehring 2011 – B), and that is why this oyster may emerge in the natural environment of Poland as a result of unaided expansion. However, considering the fact that this species does not occur in the neighbouring countries of Poland, the probability of its emergence is evaluated as low. The Pacific giant oyster occurs in the Danish straits, off the Danish, Swedish and Norwegian coast (Dolmer *et al.* 2014 – I). However, according to the HELCOM, the Danish straits are not a part of the Baltic Sea. Moreover, there is a physiological barrier in the form of low salinity (7 PSU), significantly limiting reproduction, development of larvae, and growth of the Pacific giant oyster (DAISIE 2008 – B, Dolmer *et al.* 2014 – I, Zhao *et al.* 2012 – P).

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 Pacific giant oyster may be introduced to the natural environment as a result of unintended human actions together with ballast waters or on hulls of ships (Miossec *et al.* 2009 – I, Nehring 2011 – B, Angles d'Auriac *et al.* 2017 – P). However, one should remember that on Sept. 8th, 2017, the International Convention for the Control and Management of Ships' Ballast Water and Sediments has entered into force, and in this connection, shipowners will be obligated to remove the living organisms from the water before its release from ballast tanks to the environment in the port of destination. In practice, it may limit the potential release of the Pacific giant oyster larvae to the natural environment of Poland substantially. However, the control of organisms introduced on the

	hulls of ships is lacking. Thus, one may suppose that more than 10 larvae of this species will be introduced to the natural environment of Poland during a decade.

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

X	low
	medium
	high

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

acomm08. Comments:

The Pacific giant oyster is very widespread and farmed in many countries of the world (Mortensen *et al.* 2017 – P). In most locations, it has been introduced by humans intentionally, to substitute native oyster species which have disappeared because of diseases or overfishing (Leppäkoski *et al.* 2002, Wolff and Reise 2002 – P, CIESM 2003, NIMPIS 2018 – B). In the natural environment of Poland, conditions unfavourable for the Pacific giant oyster farming occur, but the import of alive animals of this species for culinary purposes cannot be excluded. On this account, a potential risk of introduction of the Pacific giant oyster to the natural environment of Poland as a result of an intentional release exists. However, it seems to be low, not exceeding one case 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 native rangelands of the Pacific giant oyster are constituted by the coasts of Japan and Korea, located in lower latitudes of the temperate and subtropical zones (Miossec *et al.* 2009 – I). According to the climatic similarity map of Poland, included in the manual for the Harmonia^{+PL} risk assessment procedure, conditions for this species to settle down are unfavourable. However, taking into account its tolerance to low temperatures (Strand *et al.* 2011, Hanstén 2017 – P), and the fact of its occurrence in regions with similar or higher latitude, *e.g.* off the northern coast of the Wadden Sea or Norway (Angles d'Auriac *et al.* 2017, Reise *et al.* 2017 – P), it seems that the climatic requirements of the Pacific giant oyster are met partially in Poland, and in this connection, they were defined as moderately favourable for its settling down.

a10. Poland provides **habitat** that is

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

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

acomm10. Comments:

Owing to a vast tolerance to environmental conditions, the Pacific giant oyster is farmed successfully in many regions of the world (Cultured Aquatic Species Information Programme 2005 – B). It prefers hard surfaces, where it exhibits a sedentary mode of life, attached to rocks or mollusc shells, but it lives also on a muddy and muddy-sandy sea bottom (NIMPIS 2018 – B). However, probably the most significant factor preventing settling down, survival and reproduction (formation of a permanent population) of the Pacific giant oyster in Poland is constituted by the low salinity. Despite the fact that the species is able to tolerate values of salinity lower than 10 PSU, its optimal growth occurs only at 20-25 PSU (Quayle 1988 – P, DAISIE 2008 – B, Zhao *et al.* 2012, Hanstén 2017 – P). It is probably for this reason that the Pacific giant oyster has not settled down in the Baltic Sea yet (AquaNIS Editorial Board 2015 – B). Another inconvenience for the species occurring in Poland may be constituted by lacking sea tides, and as it is known, the Pacific giant oyster occurs in the tides zones most frequently (most abundantly). Considering the above, basic habitat conditions for the Pacific giant oyster are not met in Poland.

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	high **X**	level of confidence

acomm11. Comments:

Dispersion from a single source (data type: A) / Population expansion (data type: B)

The Pacific giant oyster is not settled down in Poland, however if the settling down occurred, it is probable that, due to the occurrence of a larval stage, both types of dispersion from a single source, and population expansion would be high. Drift of the planktonic larval form is possible due to 20-30-day duration of this phase, enabling a great-distance dispersion of the Pacific giant oyster (Ruesink *et al.* 2005, Schmidt *et al.* 2008 – P). However, it is hard to estimate the dispersion rate without using a specific model, as it is determined by many factors. According to such a model, larvae of the Pacific giant oyster travel a distance from 5 to 15 km (50 km at the most) in the Wadden Sea, before they settle down on a hard sea bottom (Miossec *et al.* 2009 – I).

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:

The Pacific giant oyster has not settled down in Poland, however if it occurred, the probability of human-assisted dispersal of a specimen or its propagules to a distance longer than 50 km would be high. Humans may contribute into the dispersion of the species inadvertently, by the sea transport. The larvae may be transported not only in the ballast tanks, but also on ship hulls, because they have the ability to attach to any hard surface (Miossec *et al.* 2009 – I).

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:

The Pacific giant oyster is a filtrator feeding on dissolved organic compounds and phytoplankton (Ruesink *et al.* 2005 – P). There is no literature data on impact of the species on fitoplaknton. It can be assumed, therefore, that if the species was established and widespread in Poland, in the worst case scenario it would cause only small decrease in populations of native species that are not species of special concern. The impact of the Pacific giant oyster was assessed as low.

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

X	low
	medium
	high

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

acomm14. Comments:

The Pacific giant oyster competes with other species over the food and living space. By the competition over the living space, it may affect, most of all, a native bivalve species, the blue mussel *Mytilus edulis*, and thus, the species living together with it in an association (Nehring 2011 – B, Herbert *et al.* 2016 – P). However, it is known that the Pacific giant

oyster offsets losses in the blue mussel *Mytilus edulis* abundance, by taking over its function, as well as creating a habitat for many of its companion species, thereby contributing into an increase, in fact, the local biodiversity (Markert *et al.* 2010, Herbert *et al.* 2016 – P). Also, the formation of dense clusters by the Pacific giant oyster may result in a limitation of the food availability for other filter feeders, *e.g. Cerastoderma edule*, *Mytilus edulis* bivalves (Diederich *et al.* 2005; Van den Berg *et al.* 2005 – P). However, there is no unambiguous information on the scale of reduction of native species abundance by the Pacific giant oyster in the literature, because the abundance reduction in native species populations is determined by many factors. It seems that if settling down of the Pacific giant oyster in Poland occurred, it would colonise shallower regions in the coastal zone than the native *Mytilus edulis* (DAISIE 2008 – B). Therefore, it is probable that it would contribute into the reduction of the native species abundance only to a low degree.

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:

The Pacific giant oyster may breed hybrids with other oyster species, (Leitao *et al.* 2007 – P), however, due to the lack of the latter in the fauna of Poland, such a phenomenon will not occur (probability = low, effect = small).

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:

The Pacific giant oyster may be infected by various pathogens, such as viruses, bacteria or protozoa, which may be a source of numerous infectious diseases (Elston 1993 – P). The most dangerous, causing mass mortality of the species, include the ostreid herpesvirus 1 (Os-Hv 1), which may also infect other bivalve species (Lynch *et al.* 2012 – P, Dolmer *et al.* 2014 – I, Renault *et al.* 2014, Hanstén 2017 – P). This pathogen has been found recently also in *Mytilus edulis*, which is only its carrier (O' Reilly *et al.* 2017 – P). The Pacific giant oyster is also a host for *Haplosporidium nelsoni* causing the MSX disease, which has led to death of 50% of oysters in the United States (DAISIE 2008 – B). Despite the fact that no pathogens which could cause diseases in native bivalves have been introduced to Europe together with the introduction of the Pacific giant oyster (Cultured Aquatic Species Information Programme 2005 – B), transmission of a number of parasites, including *Bonamia ostreae*, *Bonamia exitiosa*, *Perkinsus marinus*, or *Perkinsus olseni* (Enriquez-Espinoza *et al.* 2010, Lynch *et al.* 2012 – P), included in the list of the World Organisation for Animal Health (OIE), is attributed to this species. However, there is no information on the occurrence and adverse effects of these pathogens on the bivalves being native species in Poland, *i.e. Mytilus edulis* and *Cerastoderma glaucum* (Rowley *et al.* 2014 – P).

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

	low
X	medium
	high

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

acomm17. Comments:

The Pacific giant oysters, living in high densities, are forming reefs and becoming a habitat for settling of larvae and adults of benthic organisms, thus increasing the biological diversity (Ruesink *et al.* 2005 – P). While occurring in a high density, the species may also change a number of physico-chemical parameters of water and sediment significantly, *e.g.* by disturbing the carbon or ammonia nitrogen cycles, or by excessive respiration (Lejart *et al.* 2012, Herbert *et al.* 2016 – P). However, there is no exact information on the scale of these changes. It seems that the impact of the species on the ecosystem is determined by many factors, and in this connection, it should be considered locally. For that reason, it is estimated that the influence of the Pacific giant oyster on the ecosystem integrity by disturbing its abiotic factors will be medium, even with the assumption that the species will settle down and spread in our country. In the worst scenario, it means that the Pacific giant oyster will cause hardly reversible changes of processes occurring in habitats which do not belong to habitats of particular care, or easily reversible changes of processes occurring in particular care habitats.

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	medium	high **X**	level of confidence

acomm18. Comments:

The Pacific giant oyster is characterised by a high filtering rate, and if it occurs in a high density, it may affect the food web in inhabited ecosystems by consumption of large amounts of suspended particles and plankton (Herbert *et al.* 2016 – P). Dense reefs of the Pacific giant oyster may improve the water clarity, but also, they may decrease the food availability for native filter feeders (Ruesink *et al.* 2005, Buestel *et al.* 2009, Dumbauld *et al.* 2009, Herbert *et al.* 2016 – P). Besides, an abundance increase of the Pacific giant oyster at the cost of a reduction of the blue mussel, may contribute into a decrease in abundance of bird populations, *e.g.* that of the Eurasian oystercatcher (*Haematopus ostralegus*) and other organisms (Wolff and Reise 2002 – P, Dolmer *et al.* 2014 – I). A high density of the Pacific giant oyster may lead to a substantial decrease in macrofauna and zooplankton, and hence, an increase in bacteria, microfauna and meiofauna (Leguerrier *et al.* 2004 – P). Therefore, it seems that the impact of the Pacific giant oyster on the ecosystem by disturbing its abiotic factors will be medium, so in the worst scenario, this species will cause hardly reversible changes pertaining to processes occurring in habitats which do not belong to habitats of particular care, or easily reversible changes pertaining to processes occurring in particular 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:

X	inapplicable
	very low
	low
	medium
	high
	very high

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

acomm19.	Comments: The Pacific giant oyster is a filtrator feeding on dissolved organic compounds and phytoplankton. Therefore the species will not have any impact on cultivated plants.

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 not a plant.

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 not a plant.

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:

The Pacific giant oyster does not affect the condition or yields of cultivated plants.

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:

The Pacific giant oyster is not a host or vector of pathogens or parasites harmful for plants, and it may not affect plant crops in any way.

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:

X	inapplicable
	very low
	low
	medium
	high
	very high

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

acomm24. Comments:

The Pacific giant oyster is a filtrator feeding on dissolved organic compounds and phytoplankton. Therefore the species will not have any impact on cultivated plants. The species does not feed on animals and it is not a parasite.

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: No influence of the species on health of an individual animal or animal production by having properties which pose a hazard at direct contact. Also, it seems improbable that the Pacific giant oyster has such properties.

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: The Pacific giant oyster may be a carrier of pathogens which potentially, may be dangerous for native (European) oyster species farmed commercially. The most dangerous, causing mass mortality of the species, include the ostreid herpesvirus 1 (Os-Hv 1), which may be dangerous also for other bivalve species (Lynch *et al.* 2012, Hanstén 2017 – P). Insofar as the commonly used in aquaculture native bivalve species *Mytilus edulis* may be a host of this virus, no adverse effect of this pathogen on its health has been found yet (O' Reilly *et al.* 2017 – P). The Pacific giant oyster is also a host for *Haplosporidium nelsoni* causing the MSX disease, resulting in mass mortality of oysters (DAISIE 2008 – B). The Pacific giant oyster is a host for a number of parasites, including *Bonamia ostreae*, *Bonamia exitiosa*, *Perkinsus marinus* or *Perkinsus olseni* (Enriquez-Espinoza *et al.* 2010, Lynch *et al.* 2012 – P), included in the list of the World Organisation for Animal Health (OIE), is attributed to this species. However, there is no information on the occurrence and adverse effects of these pathogens on the native bivalves which could be farmed in Poland, *i.e. Mytilus edulis* and *Cerastoderma glaucum* (Rowley *et al.* 2014 – P). Despite the fact that the probability of bivalve production in Poland in an open nursery (off the coast of the Baltic Sea) is low, the influence of the Pacific giant oyster on an individual animal health or animal production in Poland by transmission of harmful parasites is defined as very strong, because of occurrence of four obligatorily notifiable pathogens in this species.

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 in not parasitic.

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 Pacific giant oysters pose a direct hazard for human health because of their sharp valves. Hard and sharp shell of the Pacific giant oyster may injure skin of persons carelessly using beaches in the area of this species' clusters (Wolff and Reise 2002 – P, Miossac *et al.* 2009 – I, GISD 2015 – B). However, even when the species is widespread, such a contact of humans with the oyster seems to be incidental, in the range of 1-100 cases per 100,000 people yearly, and its consequences rather will not impact the human health. Thus, the impact of the Pacific giant oyster on human health was defined as small, for the sake of properties which pose a hazard at a direct contact.

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

	inapplicable
	very low
	low
X	medium
	high
	very high

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

acomm29.	Comments: The Pacific giant oyster is the second intermediate host of the *Gymnophalloides seoi* trematode, which is a human parasite (Lee *et al.* 1995 – P). The infection occurs while consuming raw clams. However, this parasite has been found only in Asia so far. Information on its impact on humans in this region are scarce too. It is known that it may cause gastric discomfort, and even pancreatitis in extreme cases (Lee and Chai 2001 – P). Nevertheless, these effects seem to be curable with fast diagnosis. On this account, the impact of the Pacific giant oyster on human health, resulting from the transmission of pathogens and parasites harmful for humans, is defined as medium.

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:

X	very low
	low
	medium
	high
	very high

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

acomm30. Comments:

There is no information on harmful influence of the Pacific giant oyster on real property and personal possessions.

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
	moderately negative
	neutral
	moderately positive
X	significantly positive

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

acomm31. Comments:

The Pacific giant oyster is a widespread and commonly farmed species globally, yielding significant economic profits (Miossec *et al.* 2009 – I). It is one of two non-native invertebrates which may be farmed in the EU countries without permission (EC 2007 – P). However, a large scale trade is difficult because of a relatively short shelf life and consumer preferences pertaining to live and fresh oysters. Canned oysters, frozen oysters or oysters prepared in another way constitute only a small part of the market (Hanstén 2017 – P). In many countries, introduction of the Pacific giant oyster farming has led to creation of a sustained aquaculture, providing a direct profit for thousands of farmers and other entrepreneurs connected with this industry branch (*e.g.*, manufacturing the equipment needed for the aquaculture). Also, an indirect influence of the Pacific giant oyster aquaculture on the economy is very important, as it is connected with permanent formation of societies in poorly developed coastal regions, which plays an important role in the management of the coastal zone itself (CABI 2018 – B).

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

	significantly negative
	moderately negative
	neutral
X	moderately positive
	significantly positive

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

acomm32. Comments:

The Pacific giant oysters affect the surrounding ecosystem considerably. By forming three-dimensional reef-like structures, they increase the diversity and complexity of the soft sea bottom habitat, thus becoming an environment for settling of larvae and mature benthic organisms, so they are increasing the biological diversity (Ruesink *et al.* 2005 – P). Moreover, the Pacific giant oysters are characterised by a particularly rapid filtration rate,

	so their dense reefs may contribute into the improvement of water quality, purifying it from the suspension, which also contains various types of contaminants (Ruesink *et al.* 2005, Herbert *et al.* 2016 – P).

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	medium	high **X**	level of confidence

acomm33.	Comments: The Pacific giant oyster forms dense reefs on the sea-coast, decreasing its recreational value considerably (Herbert *et al.* 2016 – P). On the other hand, the oyster is attractive for the culinary sake and may be considered a desirable organism.

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	high **X**	level of confidence

acomm34.	Comments: There are no premises to think that the effect of the climate change will alter the probability of introduction of the species to Poland. Predictions for the Baltic Sea anticipate that the climate changes will be accompanied by a further decrease in the water salinity (IMGW 2014 – I). Development of the Pacific giant oyster's larvae occurs at 19-35 PSU, while the salinity optimal for growth amounts to 20-25 PSU (DAISIE 2008 – B, Zhao *et al.* 2012 – P, Dolmer *et al.* 2014 – I). The temperature increase in the predicted range does not appear to contribute into overpassing this barrier. On the other hand, the temperature rise may alter the water density, thereby the sea currents, which, as a consequence, may affect the spreading of the Pacific giant oyster's larvae (Birchenough *et al.* 2015 – P).

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
X	not change
	increase moderately
	increase significantly

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

acomm35. Comments:

It is improbable that the climate change will contribute into overpassing the low salinity barrier, preventing survival and reproduction of the Pacific giant oyster in Poland. As a matter of fact, the low salinity tolerance increases with temperature, but the average salinity value in Polish Marine Regions seems to be significantly below the value tolerated by this species (Zhao *et al.* 2012 – P). Moreover, the predictions for the Baltic Sea anticipate that the climate changes will be accompanied by a further decrease in the salinity (IMGW 2014 – I). Additionally, the marine water warming may contribute into a pH decrease (a so-called acidification), which may hinder the formation of calcareous structures by the Pacific giant oyster's larvae (Birchenough *et al.* 2015 – P).

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
X	not change
	increase moderately
	increase significantly

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

acomm36. Comments:

It is improbable that the temperature rise in the predicted range can contribute into spreading of the Pacific giant oyster in Poland, if it is not settled down.

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
X	not change
	increase moderately
	increase significantly

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

acomm37. Comments:

If the status of the Pacific giant oyster in Poland will not change as a result of the climate change, *i.e.* there will be no permanent population, the abundance and spreading of the species will not change, and in this connection, it is unlikely that its impact on the natural environment will alter.

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 Pacific giant oyster does not affect the condition or yields of cultivated plants.

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:

If the status of the Pacific giant oyster in Poland will not change as a result of the climate change, *i.e.* there will be no permanent population, the abundance and spreading of the species will not change, and in this connection, it is unlikely that its impact on the animal production (the aquaculture of other bivalves) in Poland will alter.

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:

If the status of the Pacific giant oyster in Poland will not change as a result of the climate change, *i.e.* there will be no permanent population, the abundance and spreading of the species will not change, and in this connection, it is unlikely that its impact on the human health will alter.

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

	decrease significantly
	decrease moderately
X	not change
	increase moderately
	increase significantly

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

acomm41. Comments:

If the status of the Pacific giant oyster in Poland will not change as a result of the climate change, i.e. there will be no permanent population, the abundance and spreading of the

species will not change, and in this connection, it is unlikely that its impact on other domains changes, particularly that there is no documented information on the impact of the species on port infrastructure or ships.

Summary

Module	Score	Confidence
Introduction (questions: a06-a08)	0.33	1.00
Establishment (questions: a09-a10)	0.25	1.00
Spread (questions: a11-a12)	0.88	1.00
Environmental impact (questions: a13-a18)	0.40	0.90
Cultivated plants impact (questions: a19-a23)	0.00	1.00
Domesticated animals impact (questions: a24-a26)	0.50	1.00
Human impact (questions: a27-a29)	0.38	1.00
Other impact (questions: a30)	0.00	1.00
Invasion (questions: a06-a12)	0.49	1.00
Impact (questions: a13-a30)	0.50	0.98
Overall risk score	0.24	
Category of invasiveness	potentially 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:

The Pacific giant oyster is included in the list of the 100 most invasive alien species in Europe (DAISIE 2008 – B). Its presence has not been found in Poland, however it is listed among alien species of plants and animals, which, while released to the natural environment, may endanger native species or natural habitats. It is one of two non-native invertebrates which may be farmed in the EU countries without permission (EC 2007 - P). The Pacific giant oyster is a widespread and commonly farmed representative of the *Ostreidae*. From the beginning of the 20th century, it is farmed successfully almost all around the world. It is characterised by a rapid growth and high fertility, so it is probable that while introduced to a new environment, it may displace the naturally occurring organisms after its acclimatization. However, despite its broad range of ecological tolerance, it seems that the low water salinity of the Baltic Sea, in connection with moderately favourable climatic conditions, will prevent it from settling down in Poland.

After carrying out the risk assessment for Poland, the Pacific giant oyster was classified in the category “invasive alien species of low significance”. The example of the Pacific giant oyster indicates that an alien species may be invasive in one ecosystem, while not being invasive in another ecosystem. The invasiveness is determined by many factors occurring locally, and on this account, one should not transfer the information on adverse effects of a

species from other ecosystems without a thorough analysis of its biology and ecology in connection with biotic and abiotic environmental factors.

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