2016-07-29

# Answers by the Swedish Agency for Marine and Water Management on the US and Canadian review and analysis on the risk assessment of American lobster (*Homarus americanus*)

Sweden received preliminary reviews and analysis of the risk assessment (RA) of American lobster (*Homarus americanus*) from USA and Canadian authorities on 7th respectively 8th of June 2016. The three documents are referred to as followed:

US1 Shank, B (National Marine Fisheries Service, Northe ast Fisheries Science Center, USA), Conor McManus, M (Rhode Island Department of Environmental Management, USA), Pugh, TL (Massachusetts Division of Marine Fisheries, USA), Reardon, KM (Maine Department of Marine Resources, USA) and Shields, J (Virginia Institute of Marine Science, The College of William & Mary). Preliminary review and analysis of Sweden's Risk Assessment on the potential impacts of the American lobster trade in Swedish waters

US2 Steneck, RS, University of Maine's School of Marine Sciences

Can Department of Fishery and Oceans, Science sector. A preliminary Analysis of the Swedish Risk Assessment of American Lobster (*Homarus americanus*)

Department of Fishery and Oceans have reviewed the RA version which was adopted in December 2015. The RA have, however, been updated with new versions twice since then, on 29th of February 2016 and on 25th of April 2016. Both have been available online in the European Commission's database here[1].

New information is presented in the US/Canadian reviews, which has clarified the RA further. The information has been incorporated in the RA with track changes and described below. The latest version can be found online here[2].

## General comments

The RA has been produced using UK non-native organism risk assessment scheme, version 5. The methodology in the UK assessment scheme meets the minimum standards according to Article 5.1 in the Regulation (EU) no 1143/2014 of the European Parliament and of the Council on the prevention and

[1] https://circabc.europa.eu/faces/jsp/extension/wai/navigation/container.jsp

[2] Risk assessment of American lobster (*Homarus americanus*). Swedish Agency for Marine and Water Management https://www.havochvatten.se/download/18.1f4499311538d55bb494594b/1461928519265/risk-assesment-american-lobster.pdf

management of the introduction and spread of invasive alien species, as wells as IPPC (International Plant Protection Convention) standards that are recognised by the Sanitary and Phytosanitary (SPS) Agreement of the World Trade Organization (WTO, 1994). Information about the scheme, link to where more information can be provided and other recommendations and criteria that have been taken into account in the RA are found in the RA preamble on page 5. The RA is based on the best available scientific evidence available at time.

There is a major difference between assessing the likelihood that establishment will occur and assessing the risk that establishment may occur. Documented establishment of *H. americanus* in Europe is exactly what we want to avoid. The largest difference between the North American reviews and the Swedish RA is how the precautionary principle is handled. The US and Canadian scientists, however, seem to focus on showing that the risk is too small to be taken into account. However, we do agree on the statement from Shank et al. (p.17) "*without a true quantitative understanding of how H. americanus would influence the native species' essential habitat and resources, it is difficult to predict commercial and recreational impacts. Thus, it is uncertain how a H. americanus introduction to European waters would influence harvests on H. gammarus and other indigenous European species.*"

Prevention is generally more environmentally desirable and cost-effective than reaction after the fact. Priorities when working with invasive alien species should therefore be given to species that are not yet present or are at an early stage of invasion. *The precautionary principle* plays an important role when invasion are not the fact. Sweden has taken into account recommendations by the Convention on Biological Diversity (CBD) on the precautionary principle towards non-native species, as well as the EU-commission non-paper – communication from the Commission on the precautionary principle (COM/2000/0001 final), among others. In the non-paper it is stated that the dimension of the precautionary principle goes beyond the problems associated with a short or medium-term approach to risks, also taking into account concerns of the longer run and the well-being of future generations. The implementation of an approach based on the precautionary principle should start with a scientific evaluation, as complete as possible, and where possible identifying the degree of scientific uncertainty.

There is also a large difference in how data is interpreted. The US/Canadian reviews/analysis does not consider possible long term effects. The fact that no successful establishment of *H. americanus* has been recorded after intended releases is no guarantee that the same species will not be successfully invasive in another place or time. It is well known that establishment often is a critical factor, and that this often is delaying the invasive process. The occurrence of a prolonged time lag between first record and a species becoming a plague is more of a rule than an exception. It is necessary to bear the precautionary principle in mind when discussing risks of potential establishment.

There are certain species characteristics that determine their ability to live in a particular area and to co-exist with other species around them. One or more of these characteristics can determine how successful a particular species is relative to another. US1 (p. 4-5) lists a number of invasive attributes and conclude that that many of these are interrelated. We agree that a mix of factors of individual species characteristics, as well as biotic and abiotic factors

influences invasiveness. We would like to add that it is needed to consider the long term effects. Example of this is snow crab (*Chionocetes opilio*) and red king crab (*Paralithodes camtschaticus*) that after a slow start now successfully have invaded the Barents Sea (Sundet and Bakanev 2014; Orlov et al. 1978).

## Detailed comments on US1, US2 and Can

All papers in some parts lack references to relevant scientific literature and many statements therefore seem speculative.

### *US1- Shank et al. Preliminary review and analysis of Sweden's Risk Assessment on the potential impacts of the American lobster trade in Swedish waters*

***US1 (p. 6)****:" recent research emphasizes the importance of propagule pressure, or the number of individuals, in invasion success (review by Simberloff 2009). Also that multiple introduction events increase the propagule number and the larger the propagule size the makes it more probable likelier that some introduced individuals will encounter appropriate ecological conditions and avoid environmental disasters."*

*Comments*: Indeed, we find that the propagule pressure is an important factor and we consider the accumulated risk high enough to exceed thresholds for successful establishment.
Indeed, we agree and refer to the geographical distribution of individual findings of live *H. americanus* in the RA area. It is likely that the majority of introductions will not be randomly scattered along the European coasts, but that they will occur repeatedly at a restricted number of hotspots near holding facilities, fish markets, etc. If this is the case, the probability of *H. americanus* individuals finding a conspecific for mating is not as low as indicated by US1. The large release in southern parts of UK is an example of this, where 361 *H. americanus* were released of which 133 have been recaptured and reported to date. Three of them were females carrying eggs.

Furthermore, the fact that *H. americanus* has been proven to hybridise with native *H. gammarus* increases the risk of negative effects on the biological diversity and a precautionary approach is therefore necessary.

***US1 (p. 6)****:"The lack of reports of H. americanus, before and after the findings during three months in Swedish Waters in 2014 suggests that a large portion of released individuals were recaptured by the fishery. They also comment that information is not provided on where each of these recaptures happened, which of these individuals still had bands on their claws, or how they were collected."*

**Comments:** In Sweden, lobster fishery is restricted to the period between the end of September and April. The absolute majority of catches are between September and November, before the water temperature is too low. Therefore, it is natural and logic that catches of *H. americanus* were restricted to three

months in 2014. In addition, dispersal of *H. americanus* from the site of introductions lowers the densities, and we cannot be sure that all *H. americanus* were caught. Dispersal obviously makes the chances of recovery from an illegal introduction lower.

The Swedish lobster fishery to a large degree consists of recreational fishery (see also p. 72 in RA, appendix 2), and the fishery as a whole is therefore data poor. The collection of *H. americanus* was conducted through a voluntary effort, where every suspected *H. americanus* was rewarded monetarily. All lobsters were caught in standard Swedish lobster pots with escape openings of 54 mm. Table 3 in the RA has been updated with information on coordinates and which lobsters had rubber band.

***US1 (p. 7)****:" examples of established invasive alien species where they question if the establishment would have been successful with a much lower propagule pressure. A few lines later, they state that snow crab (Chionoecetes opilio) successfully invaded the Barents Sea, but via unknown vectors and with unknown initial numbers. In the late 1990s there were 15 individual crabs reported over the course of four years (see Agnalt et al. 2011), whereas by 2014 C. opilio was considered a major component of the Barents Sea ecosystem and a commercial fishery has developed (Hjelset 2014)."*

**Comments:** Indeed, the population growth often is slow initially in establishments of invasive species. It is therefore vital to consider the precautionary principle when using monitoring data from early phases of a potential invasion to predict further development. Hence, the fact that no successful establishment of *H. americanus* has been recorded after the recorded intended releases is no guarantee that the same species will not be successfully invasive in another place or time. There are several examples of this, for example in Sweden with Pacific oyster (*Crassostrea gigas*) (Nehring 2011). On longer time scales there are also many examples of invasive species where introductions of only a few of individuals have resulted in very large populations. There have been attempts to release *H. americanus* outside its native range as described in the RA. It must be emphasized that these attempts have not been followed up, or only to a very limited extent.

***US1 (p. 7)****:"H. americanus does not fit well into any category within the EU Commission's potential and listed invasive species, being solely a live seafood product whose import and export is intended for human consumption and not for propagation.*"

**Comments:** We disagree with this statement. Many plants on the list of union concern that are now considered pests were introduced to Europe as ornamentals, e.g. *Cabomba caroliniana, Hydrocotyle ranunculoides, Trachemys scripta*.

***US1 (p. 8)****: "An intermediate interbreeding scenario where individuals of both species prefer to mate with conspecifics but will mate interspecifically if a mate of the same species cannot be located. Under this scenario, the potential*

*for hybridization actually functions to deter the establishment of populations of H. americanus.*"

**Comments:** We agree that an intermediate scenario is likely, but the fact that three *H. americanus* females carrying hybrid eggs have been found in Norwegian and Swedish waters proves that homarid species do mate interspecifically. Of the 7 ovigerous *H. americanus* females caught in Norway, 2 had hybrid eggs (29%) and of the 4 ovigerous females caught in Sweden, 1 had hybrid eggs (25%). That hybrid offspring is so common in ovigerous American females in Europe shows that interspecific breeding is not one isolated event, but has occurred repeatedly, and can possibly even be regarded as common. All occurrences of hybrid eggs were confirmed by DNA analysis of micro-satellite data in two separate labs, Institute of Marine Research, Bergen, Norway and University of Belfast, North Ireland. The method is described in Jørstad et al. 2007. The same microsatellites have been used by Canadian researchers when comparing *H. americanus* populations in Canada (Kenchington 2009). A number of reports and popular articles are available in Scandinavian languages, in addition to those considered from USA/Canada. We want to emphasize that even if these results are not yet published in peer-reviewed papers, we have no cause to doubt the authenticity of findings of *H. americanus* or of females with hybrid eggs.

***US1 (p.8)****: "Presumably, any introduction of H. americanus would initially constitute a very small number of individuals compared to the local, resident population of H. gammarus"*

**Comments:** We do not agree with this claim. As shown by the UK release event where 361 lobsters reached the wild, the numbers of released lobsters are not always "very small" and may even be higher than local *H. gammarus* densities.

***US1 (p. 8)****: "There are multiple factors in place to significantly and rapidly remove H. americanus genes from the general population. Fertile hybrid lobsters would have to exhibit an otherwise enormous selective advantage over H. gammarus to counter this and for H. americanus genes to proliferate.*"

**Comments:** We agree that there are several factors that could delay establishment. But this does not mean that establishment is permanently hindered. Again we refer to the precautionary principle.

***US1 (p.9)****: "Successfully establishing a population in another ecosystem populated by a sibling species would probably require a large propagule of individuals that are not effectively recaptured by the European lobster fishery in order for conspecific encounter rates to reduce the rates of hybridization and overcome the effect of diffusion over time. Further, for the population to establish and grow, environmental conditions would have to remain locally favourable and fishery exploitation would have to remain low enough for individuals to reach sexual maturity, given that they would be presumably recognized as alien and removed by the fishery not from legal size but from the size of first capture."*

**Comments:** We find this argumentation speculative, but would like to comment on some of these statements.

As stated above, we find it likely that the majority of introductions are not randomly scattered along the European coasts, but that they are most likely to occur repeatedly at a restricted number of hotspots near holding facilities, fish markets, etc. The numbers of released *H. americanus* are not always low, as seen in the example of the recent release event in UK. If this is the case, the probability of *H. americanus* individuals finding a conspecific for mating is not as low as indicated by US1.

That the environmental conditions are locally favourable has been shown by the large number of *H. americanus* caught in European waters, also indicated by the fact that ovigerous females have been found repeatedly over a large geographic area.

The fishery exploitation in Sweden is restricted to the period between the end of September and April. The absolute majority of catches are between September and November, before the water temperature is too low. Only standard Swedish lobster pots with escape openings of 54 mm are allowed in the lobster fishery. Juveniles are therefore not captured by traditional fishery. There are no other fishing gears allowed at the Swedish coast that can trap lobster juveniles. Moreover, in certain areas the fishery pressure on lobsters may be high during these months, but during the rest of the year no lobster fishery is taking place. Also, in certain protected (22 areas) and military areas no lobster fishery is allowed at all and these may provide refuge to *H. americanus* as well as *H. gammarus*. Therefore, the fishery pressure in Sweden is not so high as to be guaranteed to deplete any influx of *H. americanus*.

In the UK release event, so far only about 1/3 (133 out of 361 individuals) of the released lobsters have been caught (recapture fishery by commercial fishermen, and a specifically chartered vessel operating under direction of UK government), showing that even a high fishery effort is not guaranteed to capture all *H. americanus* from a known release site, much less unknown numbers of lobsters from unknown release sites.

**US1 (p. 10-13)**: "*Water temperatures occupied by H. americanus generally range from 5°C to around 20°C (Aiken and Waddy 1986), although they can temporarily withstand temperatures as low as -1°C to as warm as 30°C (Harding 1992). Colder waters in the winter (6° to 8° C; Aiken and Waddy 1986, Waddy and Aiken 1995) provide proper temperatures for ovarian development and the synchronization of molting and spawning cycles (Waddy and Aiken 1995). Larval settlement is most successful in water temperatures of at least 12°C (Annis et al. 2013).*"

**Comments:** Regarding the calculation on temperatures, we find it unclear which geographical regions the temperature minima and maxima were taken from and are meant to represent. However, from what we can see, the modelling of temperatures presented in the US1 report was conducted using temperatures from the regions where *H. americanus* are most abundant in their native range (i.e. Gulf of Maine, Nova Scotia and the southern parts of the Gulf of St. Lawrence). However, *H. americanus* are found as far south as Cape Hatteras in

North Carolina, albeit at moderate densities. The upper summer temperatures at Cape Hatteras are about 26°C https://www.nodc.noaa.gov/dsdt/cwtg/satl.html), which is higher than the upper sea temperatures reached in the south of the UK (normally around the 18°C mark) (Paul Stebbling pers. comm. 28 June 2016).

The results presented in US1 also suggest that upper summer temperatures are a limiting factor in the likelihood of *H. americanus* establishing in parts of the Europe, but appear to only consider a limited thermal range of temperatures in which *H. americanus* are found, especially when taking into account summer maxima. However, since the full thermal ranges in which *H. americanus* can be found seem not to be taken into account, the analysis presented in the report may be too conservative, and therefore incorrect in its conclusions.
The conclusion from the experts in the Irish Marine Institute is that the American lobster could breed in European waters from Norway to the Bay of Biscay, and that suitable habitat for the species is present over the entire region (comm. in 29 June 2016). They also observe that in fact the latitudinal range over which suitable temperatures occur in Europe is much wider than off the east coasts of America and Canada since the latitudinal gradient of suitable temperatures is steeper on the American side than the European side. The Irish Marine Institute informs that "*Cold winter temperatures followed by warmer spring summer regimes have the effect of synchronising spawning. If the seasonal differences are less pronounced a longer spawning season and a longer moulting season is expected. There will be lower level of synchrony among individuals in the population in a temp regime which is less seasonally pronounced …. [but]… the H. americanus does not experience very low winter temperatures in the south of its range in Rhone Island.*"

Higher winter temperatures at a certain depth in Europe than in North America may induce *H. americanus* in European water to migrate to greater depths where the temperature is lower. Presumably, if there is a need in *H. americanus* for low (< 5°C) water temperatures during winter for normal maturation of testes and ovaries, in many European waters they are able to migrate to deeper waters where these temperature requirements are met.

**US1 (p.14)** *"Figure 3. The biplot of winter minima vs summer maxima for each eco-region in (a) the NW Atlantic and (b) NE Atlantic data as assigned to nearest NW Atlantic eco-regions with representative 2.32 degreediameter circles around regional centroids. Each dot represents a pixel from the maps in Figures 1 and 2. Dots outside the circles between regions 1 and 4 in plot b correspond to excluded areas in Figure 2c." […] "Much of the habitat around England could be considered "outside" of existing NW Atlantic habitats, based on our domain criteria, but this area is "thermally between" NW regions 1 & 4, which support lobster populations in moderate densities in the NW Atlantic."*

**Comments:** We question the conclusion that the habitat around England could be considered "outside" of existing NW Atlantic habitats, especially in relation to existing habitat around England in the context of the report. We also question if the conclusions can be drawn from this simple model. And for this to be as robust as possible it should certainly make use of data from across as much of the native range as the data are available. Even with a more robust model there remain important caveats – the model is only providing information on the

realised niche (i.e. limited by interactions that may not be present in the potential introduced range) and it does not account for potential local adaptation of the introduced population, something we are now aware of has occurred in multiple invasive species.

**US1 (p. 15)**: *"H. gammarus appears to also utilize cobblestone habitat (Linnane et al. 2000a), and likely has the same reliance on structured habitat for successful recruitment"*

**Comments:** We would like to point out that the study by Linnane et al that is referred to here only showed that juvenile lobsters in the lab may settle and survive on a cobble substrate. However in a large European study (Linnane et al 2001) conducted to search for early benthic phase lobsters, not a single lobster juvenile was found in 67m² of likely cobble substrate sampled by airlift suction. Thus, this statement in US1 is not correct.

***US1 (p. 16)**: "Given the difference in movement patterns, low population densities and uncertainty regarding settlement habitat for H. gammarus, it's unclear whether H. americanus and H. gammarus would occupy the same ecological niches and influence the ecosystem via similarities in habitat utilization. Additionally, similar diets and habitats alone do not provide sufficient information to determine the degree of prospective competition between the two clawed lobsters in European waters. Moreover, the more complex European trophic level of decapod crustaceans may repress prospective H. americanus establishment.*"

**Comments:** We find that this argumentation lacks a discussion of the effects on an ecosystem level and also consideration of the precautionary principle. See further 4.03 in the RA for discussion of the likelihood of establishment of *H. americanus*.

**US1 (p. 16):** *"With taxonomically and ecologically similar predators inhabiting European waters, any H. americanus population growth would likely be countered by a dispensatory predation force." […] "Given the difference in movement patterns, low population densities and uncertainty regarding settlement habitat for H. gammarus, it's unclear whether H. americanus and H. gammarus would occupy the same ecological niches and influence the ecosystem via similarities in habitat utilization." […] "Thus, similar diets and habitats alone do not provide sufficient information to determine the degree of prospective competition between the two clawed lobsters in European waters." […] "Thus, similar diets and habitats alone do not provide sufficient information to determine the degree of prospective competition between the two clawed lobsters in European waters. "[…] "Thus, the more complex European trophic level of decapod crustaceans may repress prospective H. americanus establishment." […] "With taxonomically and ecologically similar predators inhabiting European waters, H. americanus population growth would likely be countered by a depensatory predation force."*

**Comments:** These arguments are speculative and lack references to relevant literature.

***US1 (p. 17)****: "Whether there are surveys in place in EU locations that would be capable of detecting these size classes, which may not be available to the fishery due to gear selectivity, is unclear."*

**Comments:** There are no such surveys at present. The densities of European lobster larvae are low and the early benthic phase cannot be found as discussed above (Linnane et al. 2001).

**US1 (p. 17):** *"Detection of larvae, early benthic phase, or adolescent-sized H. americanus will be necessary to identify successful reproductive output in EU waters, regardless of whether the mating act took place in North American waters prior to capture and exportation, or EU waters."*

**Comments:** We agree that this kind of research as well as more research into hybrid biology, competitiveness, fecundity and reproduction would be highly interesting, but it would take several years to undertake the appropriate studies. We also want to point out that the current document is a RA which includes qualitative estimates of risks and confidence levels, *not* a scientific proof that *H. americanus* is already established in Europe. Documented establishment of *H. americanus* in Europe is exactly the thing we want to avoid.

**US1 (p. 17):** [...] *"without a true quantitative understanding of how H. americanus would influence the native species' essential habitat and resources, it is difficult to predict commercial and recreational impacts. Thus, it is uncertain how a H. americanus introduction to European waters would influence harvests on H. gammarus and other indigenous European species."*

**Comments:** We have included a qualitative discussion in the RA about potential impacts. As described previously, prevention is generally more environmentally desirable and cost-effective than reaction after establishment. Priorities when working with invasive alien species should therefore be given to species that are not yet present or are at an early stage of invasion. *The precautionary principle* plays an important role when invasion are not the fact.

**US1 (p. 17):** *"Detection of larvae, early benthic phase, or adolescent sized H. americanus will be necessary to identify successful reproductive output in EU waters, regardless of whether the mating act took place in North American waters prior to capture and exportation, or EU waters. Whether there are surveys in place in EU locations that would be capable of detecting these size classes, which may not be available to the fishery due to gear selectivity, is unclear."*

**Comments:** No, there are no surveys aimed to detect larvae, early benthic phase, or adolescent phases of that *H. americanus,* but there are surveys that sample plankton for other purposes. However, we do question to what extent those analyses can distinguish between the homarid species, something that

may be possible in the progress of using barcoding technique in surveillance in the future. This has now been clarified in the RA point 2.01.

We agree that finding juvenile American or hybrid lobsters in Europe would indeed be proof of a more advanced establishment , but we do not agree that the lack of such findings is proof that establishment has not occurred. Since it has not been possible to find European lobster early benthic phase in Europe despite considerable efforts (Linnane et al 2001), the "evidence" of not finding *H. americanus* early juveniles is hardly comforting. If the entire European lobster early benthic (which must be present) phase can stay cryptic enough not to be found by European researchers for at least a century, so could probably any *H. americanus* of the same phase.

**US1 (p. 17): "***The Swedish RA identifies a few instances of captured egg-bearing H. americanus that, upon genetic testing, were determined to be carrying hybrid clutches (3 of the eleven tested females captured from Norway or Sweden).*"

**Comments:** We believe that 3 out of 11, 27% is an alarmingly high ratio of hybridisation, even if the total number of three females with hybrid eggs is not very high in itself.

**US1 (p.18):** *"Without a basic understanding of normal mating behavior in H. gammarus, nor sufficient experimental evidence describing species-specific mate choice for either species, it is difficult to determine the degree to which the two species might be expected to interact sexually."*

**Comments:** We agree that this kind of research would be highly interesting, but conclude that it would take several years to undertake the necessary studies. In addition, the proven fact that these species interact sexually is more important in a RA than the degree to which it occurs.

**US1 (p.19):** *The viability of hybrid lobsters produced by H. gammarus x H. americanus cross-breeding remains uncertain. Hybrid larvae have been demonstrated to survive and grow in laboratory environments, however the fertility of hybrids is unclear (see above).*

**Comments:** We agree that more research into hybrid biology, competitiveness, fecundity and reproduction, etc. would be highly interesting, but conclude that it would take several years to undertake the necessary studies.

***US1 (p.19):*** *"In fact, shell disease has been reported from Homarus gammarus; Roald et al. (1981) reported it in 12% of European lobsters sampled from Oslofjord, Norway, and the condition is quite common on the edible crab, Cancer pagurus, from UK waters (Ayres and Edwards 1982, Comely and Ansell 1989, Vogan et al. 1999)." [...]* **(p.20):** *"The recent risk assessment includes accounts of American lobsters captured in European waters, one of which exhibited shell disease when captured, and several others that developed shell disease while held in aquaria. It is unclear from these*

*reports what type of shell disease these lobsters exhibited." […] "Contrary to statements in the UK and Swedish Risk Assessment documents, no fishery in the U.S. has ever been closed in conjunction with ESD." […] "One bacterium of particular concern for ESD is Aquimarina homari, which is recently described and poorly understood but common in marine sediments and crustaceans and may be a key player in ESD (Chistoserdov et al. 2012, but see Meres et al. 2012). Aquimarina homari is not capable of initiating lesions and there is no evidence of transmissibility between hosts (Quinn et al. 2012)." […]* ***(p.21):*** *"Because ESD is an environmental disease, it requires very specific conditions to fulminate. The bacteria associated with the condition require a portal of entry, are associated with other stressors, and are present on healthy lobsters; thus the risk ESD imposes on H. gammarus is likely to be low."*

**Comments:** We would like to see relevant literature references that confirm the claim stating that epizotic shell disease (ESD) does not transmit between individuals. Quinn et al. (2012) show that *H. americanus* with abrasions to the carapace develop lesions after exposure to *Aquamarina homaria* as wells as mixture of bacteria. The bacterium most often associated with epizotic shell disease *A. homaria* has not officially been described, i.e. the gene sequence yet has to be implemented in the genebank. This makes identification of the bacterium very difficult (Ann-Lisbeth Agnalt, pers. comm., 28 June 2016). However, both the females with hybrid eggs caught in Norway showed clear visual signs of epizotic disease and based on isolations from one of the females and one male caught in 2009 there is suspicion that they indeed had ESD (Ann-Lisbeth Agnalt, pers. comm., 28 June 2016). The second female with hybrid eggs was caught only recently in Norway, and isolation from this female is underway (Ann-Lisbeth Agnalt, pers. Comm., 28 June 2016).

There is nothing in the RA that says that the fishery in the U.S. has been closed in conjunction with ESD. In 4.08, we say that ESD has caused major damage to local USA lobster fisheries. We refer to Stevens (2009): *"The incidence of diseased lobsters increased dramatically in New England waters after 1996 (Castro & Angell 2000), peaking at 30% in 2002 in Rhode Island waters (Gibson & Wahle 2005) and reaching a level of 43% in 2003 along the south shore of Long Island, New York (McKown et al. 2005). Increasing mortality of lobsters since that time has caused a change in the stock– recruitment (S–R) relationship between settling postlarvae and subsequent pre-recruit size lobsters, but a significant S–R relationship can be produced by inclusion of a component function for shell disease (Gibson & Wahle 2005)".*

***US1 (p. 22):*** *[…] "White spot syndrome virus"*

**Comments:** White spot syndrome virus was only mentioned in an earlier version of the RA dated December 2015. The RA has been updated several times since then and does not mention White spot syndrome virus.

**US1 (p. 22):** *"However, one could argue that these organisms are similar to any that might attach to ships or have larvae found in ballast water. In addition, similar if not identical fauna can be found on H. gammarus (see Fernandez-Leborans and Tato-Porto 2000; Middlemiss et al. 2015)."*

**Comments:** There is a need to work with all contributing sources of possible entry for alien and invasive alien species, and always to have the precautionary principle in mind. We agree that hitch-hiking organisms may pose a threat to European ecosystems that adds to the risk of introduction of the *H. americanus*, but as it is difficult to find a comprehensive list of all potential epifauna and parasites of *H. americanus*.

**US1 (p. 22):** "*Introductions of individuals in small numbers, long generation times, larval and adult dispersal, potential exploitation by humans, and the potential for hybridization with H. gammarus should all impede the establishment of populations in European waters.*"

**Comments:** It is likely that the majority of introductions will not be randomly scattered along the European coasts, but that they will occur repeatedly at a restricted number of hotspots near holding facilities, fish markets, etc. If this is the case, the probability of *H. americanus* individuals finding a conspecific for mating is not as low as indicated by US1. The large release event in southern parts of UK is an example of this, where 361 *H. americanus* were released of which 133 have been recaptured and reported to date. Three of them were females carrying eggs.

### *US2 - Steneck, RS, University of Maine's School of Marine Sciences*

**US2 (p.1)**: *"In the "Invasive Alien Species Fact Sheet" for Homarus americanus (van der Meeren et al 2010) every EU country in the North Atlantic is listed and the five in which H. americanus has been found, is listed as "Not established"."*

**Comments:** This reference has low relevance. Much has happened in the years between 2010 and 2016.

**US2 (p.1)**: *"[…] an alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health." Since several studies looked for, but found no evidence of, successful reproduction outside of the western North Atlantic (e.g. van der Meeren et al 2010) the first necessary requirement for establishing a non-native population has not been met.*

**Comments:** We want to point out that the current document is a RA which includes qualitative estimates of risks and confidence levels, *not* a scientific proof that *H. americanus* is already established in Europe. The RA is based on the best available scientific evidence at present time.

**US2 (p.2)**: *It seems logical that a population not known to reproduce cannot directly cause economic or environmental harm or harm to human health.*

**Comments:** This argument is speculative and lacks references to relevant literature.

**US2 (p.2-3):** "*The request asserts that the western North Atlantic and "European Atlantic region share very similar climates…" That is incorrect. Although there are overlaps of temperatures between the two regions, the annual temperature range is much greater in the native range of H. americanus." […] "In general and specifically for Homarus the average summer and winter temperatures define the distribution of the species (Fig. 1)."*

**Comments:** We question the temperatures presented in Figure 1, page 2. To our understanding the figure shows air temperature, not bottom water temperatures which are more relevant when comparing lobster habitats. More answers on temperatures can be found in our comments on US1 (p. 10-13).

**US2 (p.4)** *If we assume the EU is comfortable with the risk of those non-native species being found on the hulls of cargo ships, then the additional risk posed by the few lobsters found in Europe to date must be within acceptable levels. Certainly no double standard should be applied to lobsters that do not exist for ships.*

**Comments:** Sweden and EU by no means is comfortable with any introduction and establishment of any alien species. Our aim is to work with all contributing sources of possible entry for alien and invasive alien species, and always to have the precautionary principle in mind.

**US2 (p.5)**: *"Since the American lobster is not known to reproduce in Europe and if it ever does, the best available science suggests its populations will remain low, so the associated "risk" must be low."*

**Comments:** Both these statements are speculative and lack references to relevant literature.

### *Can - Department of Fishery and Oceans, Science sector. A preliminary Analysis of the Swedish Risk Assessment of American Lobster (Homarus americanus)*

**Can (p.1):** *A more comprehensive scientific review of the Swedish risk assessment for American Lobster requires information about the risk assessment framework or model that was used, and the methodology that was used to combine scores and assess and incorporate uncertainty. Any supporting documentation, tables, and scoring guidelines, etc. that were used to arrive at the final risk score are necessary to fully assess the conclusions that are presented in this risk assessment document.*

**Comments:** Please see above (general comments) for more information on the method. All information on the UK RA scheme is provided at http://www.nonnativespecies.org/index.cfm?sectionid=51.

Most questions have five alternative risk scores (very likely, unlikely, moderately likely, likely, very likely) and four alternative confidence levels (low, medium, high, very high).

**Can p.1**: *American lobsters have been recorded from European waters for many years (in some areas, over twenty years) yet there are no signs of establishment or invasiveness of the species in Europe (or elsewhere in the world). Many attempts to introduce American Lobsters outside of their native range have been made including the west coast of North America and parts of Europe, but all have failed. In all cases there have been no signs of species establishment, let alone invasiveness.*

**Comments:** We want to point out that the current document is a RA which includes qualitative estimates of risks and confidence levels, *not* a scientific proof that *H. americanus* is already established in Europe. Establishment of *H. americanus* in Europe is exactly the thing we want to avoid. The fact that no successful establishment of *H. americanus* has been recorded so far is no guarantee that the same species will not be successfully invasive in another place or time. There are several examples of this, for example in Sweden with Pacific oyster (*Crassostrea gigas*) (Nehring 2011). On longer time scales there are also many examples of invasive species where introductions of only a few of individuals have resulted in very large populations.

**Can (p.1-2**): *Many one-sided arguments are presented regarding the risk of American Lobster as an invasive species in Europe, without considering alternatives. For example, disease transmission from American Lobsters to European Lobsters was cited as a significant risk in this assessment. It is argued in the assessment that American Lobsters may be more susceptible to shell diseases than native European lobsters, and that they pose a risk of transmission to the native stocks. However, one could also argue that this susceptibility would leave American Lobsters at a disadvantage compared to European Lobsters, and could in fact be hindering them from establishing or spreading in Europe.*

**Comments:** This argument is now added and clarified in the RA, point 4.08.

***Can* (p. 2):** *The risk assessment relies heavily on qualitative evidence and it makes many unsubstantiated assumptions without providing studies to support them. There are several examples in the document where the likelihood of something occurring was stated as being 'high' or 'very high' with 'high' confidence, but then was followed with contradictory statements such as "it is difficult to comment on how likely…" (pg. 38).*

**Comments:** This is clarified in the RA in 1.08 and in 1.10.

***Can (p.2)*** […] *"there is no clear evidence that hybrid lobsters can successfully reproduce in the lab, and none is presented to suggest that hybrids can reproduce in the wild. If they could survive and reproduce in the wild, there is no evidence that these potential hybrids would have any type of advantage over native lobsters (they could even fare worse)."*

**Comments:** There is very little published research on hybrid lobsters (e.g. Audouin and Leglise 1972; Hedgecock et al. 1977; Carlberg et al. 1978; Talbot et al. 1984) and the results are to some extent contradictory. There is ongoing research in Norway and Sweden with hybrid larvae and juveniles hatched from wild-caught *H. americanus* females with hybrid eggs, but data from these studies have not yet been published. The research asked for by the Fishery and Oceans, Canada would take several years to produce.

Both of the *H. americanus* females with hybrid eggs caught in Norway carried their eggs until hatching and hatching success was normal (Ann-Lisbeth Agnalt and Susanne Eriksson unpublished data and pers. comm. 28th of June 2016). In Norway, eggs from a wild-caught *H. americanus* female with "pure" *H. americanus* eggs were also hatched with normal hatching success in the laboratory. The size and number of eggs of all three females were deemed normal (not reduced). Thus, egg-laying and survival of eggs in Norwegian and in Swedish waters seem not to be effected by any possible temperature differences from North American waters.

The hybrid juveniles reared from the first wild-caught *H. americanus* female with hybrid eggs in Norway 2009 are held in laboratory temperatures of around 8-9 °C during winter and up 15 °C during summer. So far, due to lack of funding, it has not been possible to test if the hybrids are sexually mature and will produce viable offspring themselves (Ann-Lisbeth Agnalt, unpublished data and pers. comm. 28th of June 2016).

Presumably, if there is a need in *H. americanus* for low (< 5°C) water temperatures during winter for normal maturation of testes and ovaries, in many European waters they are able to migrate to deeper waters where these temperature requirements are met. In *H. gammarus* there may also be reduced embryo development and larvae quality if the egg-bearing female is deprived of cold water in winter, but this is often not lethal for the entire clutch. Viable larvae are still produced, although perhaps in lower numbers (Gro van der Meeren, pers. comm., 28 June 2016).

We also want to repeat that that the current document is a RA, and *not* aiming to present scientific proof that *H. americanus* is already established in Europe. Documented establishment of *H. americanus* in Europe is exactly the thing we want to avoid.

***Can* (p.2):** *[…] "the volume of imports into the risk assessment area (i.e.: Sweden) should be used. From this number, lobsters brought in and/or held near suitable habitat should be considered when assessing risk."*

**Comments:** Imports for human consumption from North America goes directly into Sweden (pathway into EU/EES), or from another European member country into Sweden (pathway between EU/EES states). The volumes are presented in table 6-8 in the RA. There are controls on importing lobsters from third countries. These controls apply to all live crustacean shellfish, their eggs and gametes. All imports must be licensed and registered nationally. However, once they have entered into the EU *H. americanus* is much harder to control, and despite in many cases there being national legislation in place governing the holding of the species, escapes/releases are occurring on an irregular basis. There is an internal marked governed by the same rules that aim to enable goods, persons, capital and services to move freely within European Economic Area (EEA) and the three EEA EFTA states (Iceland, Liechtenstein and Norway). There are no restrictions on, or documentary requirements for imports of live lobsters within the area. In summary, it is virtually impossible to estimate the amount of imported live *H. americanus* that is held in the area of RA.

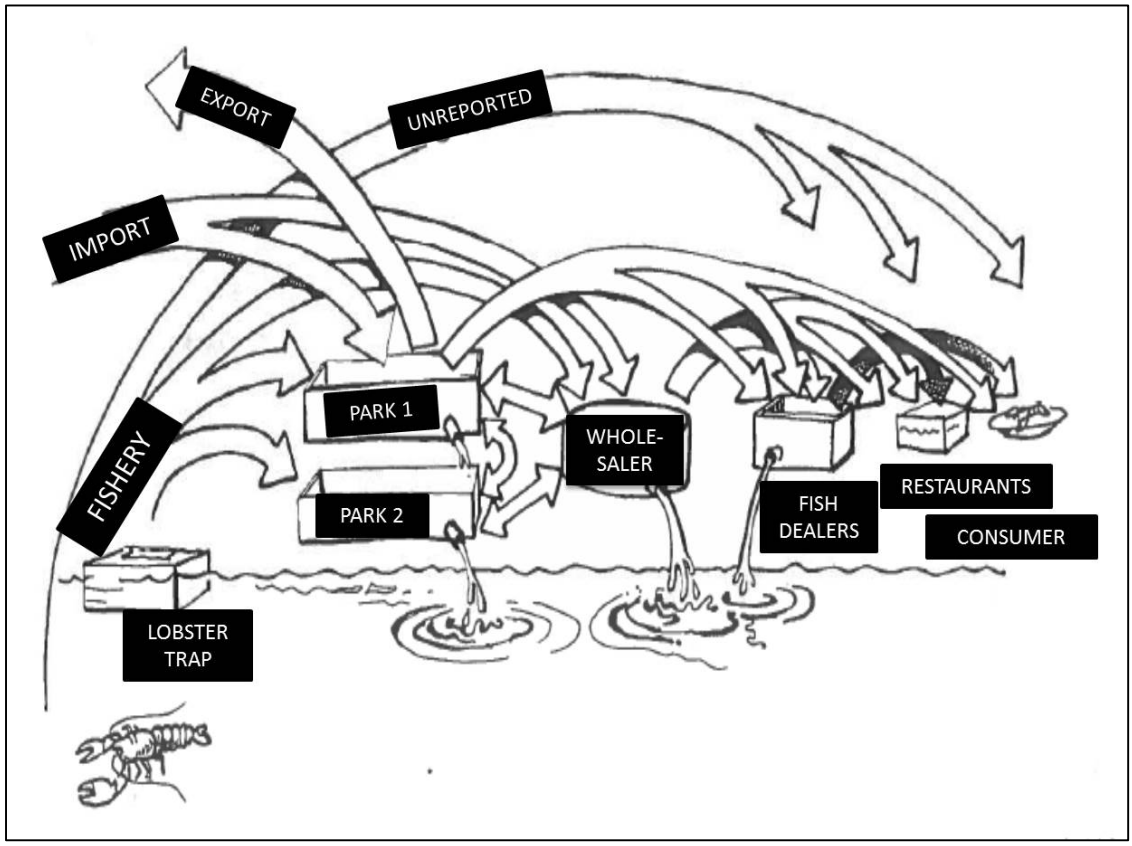


**Figure 1.** The complexity of live lobster trade (adapted from Mortensen 2002). The holding facilities can be flow-through or recirculating. In Sweden only recirculating holding system is allowed.

***Can* (p. 2)**: *[…] "it should be noted that the specific holding requirements in lobster pounds in Europe were not discussed in the risk assessment document. Details about the level of containment required by importers would be required to fully assess the risk associated with the 'arrival' element through escape from lobster holding facilities."*

**Comments:** There is a clear national legislation in Sweden where holding of live *H. americanus*, as well as other none-native Crustaceans is strictly restricted to contain land-based recirculating water systems.

**Can (p. 2)***: […] "there is no evidence presented to suggest that American Lobsters can survive across the EU, or what would comprise their suitable habitat there. […]Relatively small numbers of live adult American Lobsters discovered in certain parts of Europe does not necessarily mean that the species can survive in all other parts of Europe. […] habitat, or at least basic environmental parameters (e.g., water temperature), should be mapped to determine specifically where American Lobsters could likely survive in Europe."*

**Comments:** The RA clearly states that the potential area of spread for the *H. americanus* is the European Atlantic and North Sea coasts (not all of Europe), and we agree that high temperature is likely a restricting factor for *H. americanus* establishment in southern Europe and the Mediterranean Sea.

Regarding the calculation on temperatures, we find it unclear which geographical regions the temperature minima and maxima were taken from and are meant to represent. However, from what we can see, the modelling of temperatures presented in the US1 report was conducted using temperatures from the regions where *H. americanus* are most abundant in their native range (i.e. Gulf of Maine, Nova Scotia and the southern parts of the Gulf of St. Lawrence). However, *H. americanus* are found as far south as Cape Hatteras in North Carolina, albeit at moderate densities. The upper summer temperatures at Cape Hatteras are about 26°C (https://www.nodc.noaa.gov/dsdt/cwtg/satl.html), which is higher than the upper sea temperatures reached in the south of the UK (normally around the 18°C mark) (Paul Stebbling pers. comm. 28 June 2016).

The results presented in US1 also suggest that upper summer temperatures are a limiting factor in the likelihood of *H. americanus* establishing in parts of the Europe, but appear to only consider a limited thermal range of temperatures in which *H. americanus* are found, especially when taking into account summer maxima. However, since the full thermal ranges in which *H. americanus* can be found seem not to be taken into account, the analysis presented in the report may be misleading, and incorrect in its conclusions.

The conclusion from the experts in the Irish Marine Institute is that the American lobster could breed in European waters from Norway to the Bay of Biscay and that suitable habitat for the species is also presents (comm. in 29 June 2016). They also observe that in fact the latitudinal range over which suitable temperatures occur in Europe is much wider than off the east coasts of America and Canada since the latitudinal gradient of suitable temperatures is steeper on the American side than the European side. The Irish Marine Institute informs that "*Cold winter temperatures followed by warmer spring summer regimes have the effect of synchronising spawning. If the seasonal differences are less pronounced a longer spawning season and a longer moulting season is expected. There will be lower level of synchrony among individuals in the population in a temp regime which is less seasonally pronounced …. [but]… the*

*American lobster does not experience very low winter temperatures in the south of its range in Rhone Island.*"

Higher winter temperatures at a certain depth in Europe than in North American may only cause the American lobsters in European water to migrate to greater depths where the temperature is lower.

**Can (p. 3)**: *[…] " "After decades of known introductions of American Lobsters into European waters, there are still no signs of successful reproduction in the wild or establishment. Some effort has been made to locate juveniles and nurseries in European waters, but so far no evidence has been found. […] However there is generally a lack of support presented in the Swedish risk assessment for the assertion that American Lobsters can establish in Europe. […]"Therefore, the fact that juvenile American Lobsters have never been found in European waters supports the idea that American Lobsters are not completing their life cycle there and may not be capable of establishing."*

**Comments:** We agree that finding juvenile American or hybrid lobsters in Europe would indeed be proof of a more advanced establishment , but we do not agree that the lack of such findings is proof that establishment has not occurred. Since it has not been possible to find European lobster early benthic phase in Europe despite considerable efforts (Linnane et al 2001), the "evidence" of not finding *H. americanus* early juveniles is hardly comforting. If the entire European lobster early benthic (which must be present) phase can stay cryptic enough not to be found by European researchers for at least a century, so could probably any *H. americanus* of the same phase.

**Can (p. 3)**: *"Standard trapping techniques (e.g., lobster traps) would effectively sample for juveniles as well as adults."*

**Comments:** Swedish standard lobster pots are legally obliged to have escape openings of 54 mm diameter, thus making it highly unlikely that juvenile lobsters are caught together with the adult ones. Also Norway has similar measures to make sure that undersized lobsters are not caught in the fishery. In the Swedish fishery there are few other types of fishing gear that may catch lobster juveniles, due to their small size and presumably cryptic behaviour.

**Can (p. 3):** *"The risk assessment mentions female American Lobsters that were found in Europe with eggs; however this is not necessarily evidence of life cycle completion because females can store male sperm for over a year before producing fertilized eggs. […] American Lobster larvae require more specific environmental conditions than adults in order to survive and grow (e.g. specific temperatures, salinity, low pollution levels), which could hinder their establishment outside their native range."*

**Comments:** Both *H. americanus* females with hybrid eggs caught in Norway carried their eggs until hatching and hatching success was normal (Ann-Lisbeth Agnalt and Susanne Eriksson unpublished data). In Norway a wild-caught American female with American eggs was hatched with normal hatching success in the laboratory. The size and number of eggs of all three females were deemed

normal (not reduced). Thus, egg-laying and survival of eggs in Norwegian waters seem not to be effected by any possible temperature differences from North American waters.

The hybrid juveniles reared from the first wild-caught *H. americanus* female with hybrid eggs in Norway 2009 are held in laboratory temperatures of around 8-9 ºC during winter and up 15 ºC during summer. So far, due to lack of funding, it has not been possible to test if the hybrids are sexually mature and will produce viable offspring themselves (Ann-Lisbeth Agnalt, unpublished data and pers. comm. 28 June 2016).

We repeat that the current document is a RA which includes qualitative estimates of risks and confidence levels, *not* a scientific proof that *H. americanus* is already established in Europe.

**Can (p. 4): "***[…] it would be useful to know how far these reports were from lobster holding facilities to help assess probability of spread and to provide more information on their habitat use once released."*

**Comments:** The maps on p. 22 in the RA show the known points of capture for *H. americanus* in Europe. The majority of the catches are close to harbours or holding facilities, but several are considerable distances away from such areas.

**Can (p.4): "***[…] page 46 presents the proportion of habitat in Europe that American Lobster can establish in, implying that some habitat suitability mapping or other quantitative analysis was performed."*

**Comments:** The proportion of habitats is a qualitative estimate by European lobster experts. Our intention was to make a quantitative analysis, but the bottom substrate data for the European coastline needed to evaluate Homarid lobster habitats are not available for all countries, see for example the European database Emodnet[3].

**Can (p. 4):** *This risk assessment often refers to "massive" negative impacts of American Lobster with little more than speculation and qualitative statements to back it up. How is a score of "massive" calculated? Speculation regarding impacts in a risk assessment is acceptable when there is a lack of concrete supporting evidence, however the level of certainty in those circumstance should be 'low' or 'very low'. Yet in this risk assessment confidence surrounding impacts is stated as being 'medium'.*

**Comments:** We do not refer to "massive" impacts in the latest version of the RA. This score was only used in an earlier, preliminary version of the RA.

**Can (p. 4)***" There appears to be mixed scientific evidence for the potential mating and hybridization of American Lobster with European Lobster, either*

[3] http://www.emodnet-seabedhabitats.eu/default.aspx

*in the lab or in the wild." p.5 "Hybrid offspring would need to be able to reproduce themselves in the wild in order to pose any threat."*

**Comments:** Several *H. americanus* females with hybrid eggs have been caught in European waters and hybrid larvae successfully hatched in lab from these clutches, so the fact that the two species do mate and produce hybrid offspring cannot be disputed. We agree that the research is scarce and partly contradictory on the reproductive abilities of hybrid lobsters, and hope for more studies into this field in the future. Indeed, there are ongoing studies in both Norway and Sweden on the hybrids from the *H. americanus* females caught there. However, the results from these studies may still be several years into the future.

**Can (p.5)** *"[…] However, these reports have not been vetted through an external scientific peer-review process and do not provide the details of the procedures or techniques that were used to arrive at their findings."*

**Comments:** That the findings of *H. americanus* and hybrid eggs have not been published in peer-reviewed journals does not diminish the fact that such findings have occurred. Analyses of the hybrids have been conducted by two independent laboratories, in Norway and UK, using micro satellite data (developed in the EU-project LEAR, Mercer et al. 2001).

**Can (p.5)** *"If hybrid eggs are created, their ability to survive in the wild in European waters, grow into adult hybrid lobsters, and then these adults successfully reproduce themselves still needs to be determined. Hybridization could be actively tested for in individuals from high risk areas (e.g., Gullmarsfjord, Sweden)." […] "If hybrids were found to be able to survive and reproduce in the wild, then the ability of hybrids to out-compete native lobsters for food and space during each life stage would also need to be addressed to adequately asses the risk for impact from hybridization."*

**Comments:** We agree that the research is scarce and contradictory on the reproductive abilities of hybrid lobsters, and hope for more studies into this field in the future. Indeed, there are ongoing studies in both Norway and Sweden on the hybrids from the *H. americanus* females caught here. However, the results from these studies may still be several years into the future.

**Can (p.6)***: "Gaffkemia is a bacterial disease that can affect the shell of lobsters. It is present in both North American and European waters (Greenwood et al. 2005), and has been present in Europe since the 1950's (Egidius 1972)." […] "The high level of impact Gaffkemia on European Lobster that is suggested in the Swedish risk assessment is not supported by the literature as conflicting reports have been published (Wiik et al. 1986; Snieszko and Taylor 1947; Roskam 1957)."*

**Comments:** Although Gaffkemia has been found in Europe (as shown by e.g. Stebbing et al 2012), most writers agree that higher prevalence and outbreaks of the disease occur only in holding facilities where lobsters are held closely together. American lobsters may become infected before export but not develop

severe symptoms. Repeated introductions of such infected lobsters into natural waters in Europe could possibly increase the prevalence of the disease in wild lobsters (Charlotte Axén, pers comm. 1 July 2016).

The Norwegian researchers that we have consulted are confident that *Gaffkemia* is not present in Norwegian waters (Gro van der Meeren, Ann-Lisbeth Agnalt and Stein Mortensen pers. comm, 29 June 2016). There is also agreement among these researchers that the European lobsters in Norway do not have any tolerance towards *Gaffkemia*; if they are infected, they die.

**Can (p.6):** *"The risk assessment suggested that some larger, more visible organisms (e.g., barnacles) could hitchhike their way to Europe on American Lobsters and be introduced into the wild in Europe where they could become invasive. However, no specific species were identified in the risk assessment. Each of these species would need to be identified in order to independently assess their true risk (i.e.: likelihood of their introduction and magnitude of impact)."*

**Comments:** We agree that hitch-hiking organisms may pose a threat to European ecosystems that adds to the risk of introduction of the *H. americanus*, but as it is difficult to find a comprehensive list of all potential epifauna and parasites of *H. americanus*.

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