Draft Assessment Report: Application to amend the List of Specimens Suitable for Live Import (*Haliotis discus hannai*)

CSIRO Australian Animal Health Laboratory

October 2014

1. Introduction

This draft assessment report was prepared with assistance from Aquagestion, Chile and is based on current knowledge and information on the Japanese or Pacific abalone (*Haliotis discus hannai* Ino). Much of the information on this species' biology was sourced from the *FAO Training Manual on Artificial Breeding of Abalone (*Haliotis discus hannai*) in Korea DPR* (FAO, 1990).

2. Objectives of the draft assessment

The draft assessment was undertaken to address the potential impacts on the Australian environment, based on the terms of reference as outlined in the application process to amend the List of Specimens Suitable for Live Import, administered by the Australian Government Department of the Environment.

3. Terms of Reference

3.1 Taxonomy of the species

PHYLUM: Mollusca
CLASS: Gastropoda
SUBCLASS: Orthogastropoda
ORDER: Vetigastropoda
FAMILY: Haliotidae
GENUS: *Haliotis* (sole genus in the family)
SPECIES: *Haliotis discus*
SUBSPECIES: *Haliotis discus hannai*
TAXONOMIC REFERENCES: http://www.marinespecies.org/aphia.php?p=taxdetails&id=397083; Geiger & Owen (2012).
COMMON NAMES: Pacific abalone; Japanese abalone

GMO: Not a GMO

3.2 CITES Status

Not listed in CITES Appendices I, II or III.

Globally, there is a high demand for abalone (several species) as seafood and there is a decline in wild stocks. To meet this high demand, abalone farming is expanding in several countries.

Aquaculture of *Haliotis discus hannai* is a thriving and prosperous industry in China, producing about 50,000 metric tonnes in 2010. This species is not native to South America. *Haliotis discus hannai* was introduced into Chile specifically for commercial farming which has occurred since the late 1980s.

3.3 Ecology of the species

3.3.1 Lifespan of the species

Up to 20 years.

3.3.2 Size and weight range

The size of fully mature specimens of this species ranges from about 12 to about 18 cm shell length. Abalone grow at a rate of about 2–3 cm/year when food is not limiting; it takes 4 years to grow to the marketable size (>9 cm; ca. 150 g). In a few cases, however, growth only occurs at a rate of 1 cm/year, so that it can take more than 8 years to reach the commercial size. Under good feeding conditions, farmed abalone grow at a rate of 3–5 cm/year, particularly when the juveniles are artificially released and raised in the open seawater.

3.3.3 Species identification

Six species of abalone have been reported to occur along the Korean coasts, *Haliotis discus hannai* Ino, *H. discus discus* Reeve, *H. madaka* Habe, *H. gigantea* Gmelin, *H. diversicolor supertexta* Reeve, and *H.*

diversicolor diversicolor Reeve, but these species are quite similar in external morphology, and natural hybrids are frequently found making species identification using traditional morphological characters difficult. The phylogenetic relationship among the 6 species of Pacific abalone inferred from 16S rRNA and COI gene sequences suggested that there are 2 groups of species [*H. discus hannai*, *H. discus discus* Reeve, *H. madaka* Habe, *H. gigantea* Gmelin, Group A; *H. diversicolor supertexta* and *H. diversicolor diversicolor,* Group B] (An et al., 2005). Understanding these difficulties with speciation, morphological characters of the Japanese abalone include a blue-brown or ash-brown coloured outer surface of the shell. However, shell colour can be influenced by local environmental conditions and occasionally it may also be red.

3.3.4 Natural geographic range

Natural populations of the Pacific or Japanese abalone (*Haliotis discus hannai* Ino) occur in the coastal waters of East Asia including those of China, Korea and Japan (Wu et al., 2013).

3.3.5 Habitat

In Korea, measurement of an isothermal line is conducted in February for a water temperature of 12°C at 25 metres depth. With the isothermal line as a basis for identification, the distribution of abalone species can be divided roughly into two classifications: Northern and southern species. *H. discus hannai* are found in the northern waters (>12°C) while the southern waters are the habitat for species such as *H. gigantea, H. sieboldii, H. discus discus*, etc. Normally, abalone are found at depths down to 30 metres in the intertidal zone. Abalone have their maximum population density at depths in the range of 3–10 metres where seaweeds, their natural food, are abundant (FAO, 1990). Abalone are sedentary, nocturnal, animals that live in rock crevices during the day.

3.3.6 Diet, including potential to feed on agricultural plants

Larvae are lecithotrophic relying on their yolk sac for nutrition, although they also absorb some organic nutrients from the water column during their planktonic phase; juveniles graze on epiphytic diatoms and adults consume seaweeds.

3.3.7 Social behaviour and groupings

Like other abalone species, the Japanese abalone has a sedentary lifestyle, remaining in the same general area for its entire life. It moves around by shuffling forward on its muscular foot, which has a surface area usually equal to that of the shell.

H. discus hannai is most active when the water temperature is 15-20°C, and feeding is most voracious 2-3 hours after sunset and 2-3 hours before sunrise.

At spawning time, *H. discus hannai* tend to congregate. Spawning occurs just after sunset when the males release sperm which triggers spawning by the females.

3.3.8 Territorial and aggressive behaviours

Abalone are sedentary, nocturnal, non-aggressive, non-territorial animals living in rock crevices during the day.

3.3.9 Natural predators

Abalone predators include various species of marine finfish, crustaceans, echinoderms, molluscs and others. For example, studies have shown an average of 71 juvenile abalone shells, and a maximum of 200 shells, found in the stomach of sea perch.

The foot is a very powerful suction cup with considerable surface adhesion force. Thus, the abalone has a remarkable way of protecting itself and becoming nearly invulnerable to predators. Using its foot, it can propel forward at a considerable speed as well as cling firmly to a rock. They exhibit a galloping, zigzag escape response from predators, with the upper part of the foot extended over the edge of the shell. If the presence of a predator is sensed, the abalone instantly clamps down, pulling its shell over its soft body. In this position it is difficult for most predators to dislodge the abalone from the substrate.

3.3.10 Characteristics that may cause harm to humans and other species

No data are available but it is noted that juveniles feed on diatoms; adults are herbivores and feed on seaweed. During grazing there is potential to inadvertently consume toxic algal cysts, but algal toxins accumulate in the abalone gut, rather than in the edible foot. No instances of human poisoning are known from the available literature.

3.3.11 Anatomical features

From the veliger stage the bilateral symmetry of the abalone body develops into a spiral shape. Its body is divided into three parts: head, foot and saccate intestine. The head is located at the anterior of the body and is bilaterally symmetrical. It comprises a mouth, appendages and sensory organs. Compared to other shellfish, abalone have a developed and complex head with a pair of tentacles and two eyes at the tip of eye stalks which originate at the bottom of the tentacles. The foot of the abalone is a creeping organ of muscular tissue which lies ventrally. The well-developed foot has a broad "sole" which allows the animal to adhere strongly to rocks or other hard substrates. The epipodium that occupies the lower part of foot forms a broad-plate shape structure, while the interior surface has ten pairs of brown stripes on a grey background. Branch-shaped tentacles are typically found at the end of the epipodium. The intestinal sac is located on the dorsal side of abalone and has several internal organs. On the outside, the mantle runs from the back to the ventral margin. The abalone shell is formed by a secretion released from the epidermal cells at the front margin and tip of the mantle.

3.4 Reproductive biology of the species

3.4.1 The age at maturity (first breeding)

The abalone is a dioecious animal, with individuals of separate sexes reaching maturity, in general, after three years. As the spawning season approaches, the gonads become engorged with mature gametes. One female measuring 7–8 cm in shell length may release 1 million eggs while larger females may release up to 10 million eggs.

3.4.2 Breeding frequency

The abalone spawning season in Korea (DPR) begins in July/August when the seawater temperature is around 20°C and in some cases it lasts throughout September and/or October. The breeding season and its duration vary according to species and are closely related to environmental conditions, particularly water temperature. The spawning season for *H. discus hannai* in Japan is July to October. Research has demonstrated that Japanese abalone require a certain time period at set temperatures to attain full gonadal maturity. *H. discus hannai* becomes fully mature after 120 days at 20°C.

3.4.3 Mode of fertilisation

The female does not store sperm. Fertilisation occurs in the water column. The eggs and sperm are released from females and males respectively into the same anatomical region where the gills and anus are located. There is always a gentle flow of water out of this area and the eggs and sperm are washed out through the holes in the shell by this respiratory/sanitary current. If the mantle cavity, under the holes, becomes congested with eggs or sperm the abalone may raise its shell then quickly pull it down, creating a squirt of water out of the holes. This may occur several times to clear the eggs or sperm from the gill area.

3.4.4 Fecundity

H. discus hannai spawn 1-1.5 million eggs per 100 g wet body weight plus shell. Once fertilised, the eggs hatch in 12-15 hours to produce the swimming trocophore stage, and by 30 hours the larvae have developed a functional foot and are ready to settle. At 20°C, settled spat of *H. discus hannai* grow at a rate of 0.03-0.04 mm per day.

3.4.5 Ability of the species to hybridise with any other species

Abalone species can hybridise and the progeny are fertile (Lafarga de la Cruz and Gallardo-Escarate, 2011).

It has been reported that *H. discus hannai* can form viable hybrids. Hybrids tend to be less prevalent and persistent in the wild than their parent species. Inter-specific-induced hybridization between *H. discus hannai* and *H. discus discus* and *H*. *gigantea* has been reported.

3.5 Information on feral populations

There is no available information on whether this species has established feral populations. This species does not occur naturally in Chile and was introduced to Chile in the 1980s for aquaculture purposes as an option to diversify the local aquaculture industry.

3.6 Previous environmental risk assessments

No data are available. AQIS assesses disease introduction risk and has informed us that an import permit can be issued with the condition that the abalone are transferred to the high-level biocontainment facility at CSIRO-AAHL and used for research purposes only.

As part of an earlier successful application to list NZ Paua (*Haliotis iris*) for research purposes, CSIRO-AAHL has undertaken a similar environmental risk assessment for *H*. *iris*. Subsequently, NZ Paua was added to the List for Live Import and an import permit was issued (Import Permit Number: WT2013-000177). However, due to an outbreak of Perkinsiosis (due to infection with *Perkinsus olseni*) in the NZ Paua population in 2013 (OIE, 2014), NZ Paua have not been imported to Australia using this import permit.

3.7 Potential for establishment of a breeding population in Australia

3.7.1 Ability to find food sources

Assuming that the species does not require plankton or seaweed species/varieties that are specific to Asian waters, *H. discus hannai* should have no difficulty in finding food. Abalone are able to detect food only at close proximities. Once food is detected, the abalone glides slowly along until it reaches the alga. It then raises its foot and comes down on the plant, trapping it beneath its body. It then consumes the alga, using its small rasp-like teeth and extruding tongue.

3.7.2 Ability to survive and adapt to different climatic conditions (e.g. temperatures, rainfall patterns)

As with other species of abalone, *H. discus hannai* has a restricted temperature range. *H. rubra* and *H. laevigata* are common cold-water abalone species in Australia, with a preferred temperature range of about 8-17°C. Japanese abalone (*H. discus hannai*) seldom feed at a temperature of 8°C, while it takes in food up to 6% of its body weight at 12°C, and 15% at 20°C. So the likelihood that this species could establish a breeding population depends on, among other factors, food availability and water temperature range.

3.7.3 Ability to find shelter

Normal habitat is under stones and in rock crevices – therefore no issues with finding shelter.

3.7.4 Rate of reproducing

This species spawns throughout the year, with a peak between July and August (in Asia).

3.7.5 Any characteristics that the species has which could increase its chance of survival in the Australian environment

None known.

3.8 Potential impact if establishment in Australia occurred

3.8.1 Niche/living requirements

Haliotis discus hannai lives in shallow water relative to the habitats of the greenlip and blacklip species found in Southern Australian waters of similar temperature range. Japanese abalone are likely to be equally as susceptible to predators as the native species in these waters. Abalone are opportunistic feeders that rely predominantly on drift algal fragments for their nutrition. Competition for food and impact on native abalone habitat from a non-native species of abalone under these circumstances would be improbable.

3.8.2 Species susceptibility to, or ability to transmit, any pests or disease

No data are available concerning diseases/pests that are not already present in marine environment.

A condition of the import could be that the animals are healthy and accompanied by a health certificate from the Veterinary Authority of the exporting country which specifies freedom from the known Haplosporidium (Diggles *et al*., 2002), fungus (Friedman *et al*., 1997; Nollens *et al*., 2004) and other known diseases/infectious agents of abalone (Bower *et al*., 1994; OIE, 2014a).

With respect to our needs, all animals will be used for research only. Once imported, animals will be housed in the high-level bio-security facility at CSIRO-AAHL Geelong from where there is no possibility of escape of live animals or infectious agents, including Haplosporidia and fungi. All effluent water from animal experiments at AAHL is inactivated by heat treatment (100°C for 20 minutes) prior to release into the local sewer system.

All materials for laboratory analysis (e.g. tissues samples) will be inactivated as part of the experimental protocols. Such inactivation will include fixation in ethanol for PCR testing and fixation in formaldehyde for routine histology.

All other waste (e.g. shell) that is not used for analysis will be autoclaved prior to disposal by incineration. The standard waste parameters for autoclaves are 121°C for 45 minutes.

3.8.3 Probable prey/food sources

Larvae are lecithotrophic; adults are herbivores and feed on seaweed.

3.8.4 Impacts on habitat and local environments

The adult stages of abalone are opportunistic feeders that rely predominantly on drift algal fragments for their nutrition. As a consequence, they exert only limited pressure on algal communities. Indeed, the presence of abalone is thought to be beneficial in terms of habitat maintenance. In this sense abalone are classified as habitat responders, in contrast to sea urchins which are considered habitat modifiers. Thus, Japanese abalone are unlikely to cause adverse ecological impact should they escape into the Australian environment.

3.8.5 Any control/eradication programs that could be applied in Australia if the species was released or escaped

Unlikely. There is no evidence that *H. discus hannai* would have any competitive advantage if escape into the Australian environment occurred.

Application of lime would destroy all shellfish in an affected area, but such intervention is unlikely to be acceptable from an ecological perspective.

3.8.6 Behaviours that cause environmental degradation

None known.

3.8.7 Impacts on primary industries

None known.

3.8.8 Damage to property

None known.

3.8.9 Is the species a social nuisance or danger

No.

3.8.10 Any potential threat to humans

None known.

3.9 Import conditions to mitigate potential negative environmental impacts

It would require very large numbers (in excess of what is required in this instance i.e. research only) of animals to be released into the environment to create a substantial threat. Conditions or restrictions applied to the import of this species could include: Imported animals must be housed in bio-secure research facilities only.

3.10 Summary of proposed activity

The purpose of importing Japanese abalone (*H. discus hannai*) into Australia would be for research only. This species has been chosen because the Australian Animal Health Laboratory (AAHL) in Geelong was requested by the Undersecretary of Fisheries in Chile (via Aquagestion) to undertake trials in AAHL's high-level bio-secure aquarium facility to determine the susceptibility of Japanese abalone to the disease abalone viral ganglioneuritis caused by infection with Abalone herpesvirus (AbHV; Hooper et al., 2007; Corbeil et al., 2012). We, at AAHL, are interested in doing these trials because AAHL is a World Organisation for Animal Health (OIE) Reference Laboratory (OIE, 2014a) for this agent, and knowledge about the host range for AbHV is important information of interest to the international scientific community and government regulators.

3.11 Housing conditions

Special conditions for housing this species are not required.

Transportation: Abalone species are transported chilled (with ice packs) in a secure, insulated container such as an esky with a secured lid.

Housing: A bio-secure marine aquarium with normal, aerated seawater maintained within the temperature range of 13-20^{O}C. At AAHL there is a range of tank sizes from 2 litres (for housing single animals) up to 100 litres (for housing dozens of animals). Abalone are relatively sedentary but tank covers are used to prevent any possibility of escape. The bio-secure aquarium at AAHL is located in the high-level bio-secure area of the facility which is engineered to prevent any escape of air-borne or water-borne infectious organisms, or animals infected with disease agents.

Animal welfare considerations: Animals are for research purposes. Even though abalone are not included in animal welfare regulations, the research team have collaborated with the AAHL Animal Ethics Committee to ensure experimental abalone are treated humanely.

Disposal: At AAHL, all animals are disposed of following the completion of experiments. The animals are euthanized in a humane manner and then incinerated. For abalone, the method of euthanasia involves chilling the abalone on ice and, with a scalpel, slicing the animal through the head region.

3.12 State/Territory controls

Biosecurity Australia/AQIS: There are import permit conditions specific to live aquatic animals for laboratory use. The conditions include that the animals will be contained permanently at a Quarantine Approved Premises (approved by AQIS) – such as AAHL - and after the experiment(s) they will need to be disposed of in an AQIS-approved manner.

New South Wales: There are no specific restrictions with respect to *H. discus hannai* in NSW.

Northern Territory: No specific regulations but this species is not an allowable import to the Territory under existing NT Legislation

Queensland: The species is first considered as non-endemic and therefore possession and/or placement is not permissible under the Queensland Fisheries Act unless there is authority to do so.

South Australia: There are no specific controls on *H. discus hannai* in South Australia.

Tasmania: All abalone species are currently banned for import into Tasmania under the *Animal Health Act 1995*.

Victoria: Victoria does not have any regulations pertaining to the species *H discus hannai.*

Western Australia: All live *Haliotis* spp. are prohibited from entry into WA.

4. References

An H-S, Jee J-J, Min K-S, Kim B-L, Han S-J. 2005. Phylogenetic analysis of six species of Pacific abalone (Haliotidae) based on DNA sequences of 16s rRNA and cytochrome *c* oxidase subunit I mitochondrial genes. *Mar Biotechnol*. 7, 373-380.

Bower SM, McGladdery SE, Price IM. 1994. Synopsis of infectious diseases and parasites of commercially exploited shellfish. *Ann Rev Fish Dis*. 4, 1-199.

Corbeil S, McColl KA, Williams LM, Mohammad I, Hyatt AD, Crameri SG, Fegan M, Crane MStJ. 2012. Abalone viral ganglioneuritis: Establishment and use of an experimental immersion challenge system for the study of abalone Herpes virus infections in Australian abalone. *Virus Res*. 165, 207-213.

Diggles BK, Nichol J, Hine PM, Wakefield S, Cochennec-Laureau N, Roberts RD, Friedman CS. 2002. Pathology of cultured paua *Haliotis iris* infected with a novel haplosporidian parasite, with some observations on the course of disease. *Dis Aquat Org*. 50, 219-231.

FAO. 1990. Training Manual on Artificial Breeding of Abalone (*Haliotis discus hannai*) in Korea DPR. http://www.fao.org/docrep/field/003/ab731e/ab731e00.htm

Friedman CS, Grindley RM, Keogh JA. 1997. Isolation of a fungus from shell lesions of New Zealand abalone, *Haliotis iris* Martyn and *H. australis* Gmelin. *J Mollusc Res*. 18, 313–324.

Geiger DL, Owen B. 2012. *Abalone: Worldwide Haliotidae.* Hackenheim: Conchbooks. viii + 361 pp. [29 February 2012] page: 84.

Hooper C, Hardy-Smith P, Handlinger J. 2007. Ganglioneuritis causing high mortalities in farmed Australian abalone (*Haliotis laevigata* and *Haliotis rubra*). *Aus Vet J*. 85, 188-193.

Lafarga de la Cruz F, Gallardo-Escarate C. 2011. Intraspecies and interspecies hybrids in *Haliotis*: Natural and experimental evidence and its impact on abalone aquaculture. *Rev Aquaculture* 3, 74-99.

Nollens HH, Keogh JA, Probert PK. 2004. Haematological pathology of shell lesions in the New Zealand abalone, Haliotis iris (Mollusca: Gastropoda). *Comp Clin Pathol*. 12, 211–216.

OIE. 2014. http://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?page_refer=MapFullEventReport&reportid=14615

OIE. 2014a. Manual of Diagnostic Tests for Aquatic Animals. http://www.oie.int/en/international-standard-setting/aquatic-manual/access-online

Wu F, Ji Y, Zhao G, Gao Y, Zhang G. 2013. Development of pacific abalone (*Haliotis discus hannai* Ino) broodstock: Initial characterization of early growth traits of F_1 progeny. *J Shellfish Res*. 32, 45–49.