Recovery Plan for the endemic freshwater molluscs of Bermuda; the limpet *Ancylus bermudensis* and the pea clam *Pisidium volutabundum*

Government of Bermuda
Ministry of Home Affairs
Department of Environment and Natural Resources

Recovery Plan for the endemic freshwater molluscs of Bermuda; the limpet *Ancylus bermudensis* and the pea clam *Pisidium volutabundum*

Prepared in Accordance with the Bermuda Protected Species Act 2003

Author

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Cover photos: *Pisidium amnicum* (left) and *Ferrissia sp.* (right).
Photographs of live *Ancylus bermudensis* and *Pisidium volutabundum* are not available; therefore the above species were used for illustrative purposes only. The background is Pembroke Marsh.
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"To conserve and restore Bermuda's natural heritage"

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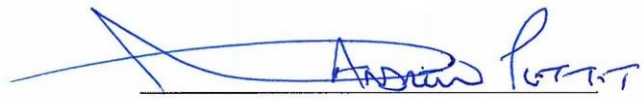
An electronic version of this recovery plan will also be made available at www.environment.bm



27th April 2020

Andrew Pettit
Director
Department of Environment and Natural Resources
Bermuda Government

Date

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I wish to express my thanks to Dr Martin Thomas for his assistance with field surveys in 2007 and to Alison Copeland who reviewed this plan. Figure 4 was created by Mandy Shailer and Figure 5 was created by Lawrence Doughty.

EXECUTIVE SUMMARY

Current Species Status:
The Bermuda freshwater limpet was first described under the genus name *Ancylus* in 1910; however this name changed to *Ferrissia* in 1917 but the new name did not appear in the Protected Species Order of 2007 or the subsequent amendment order in 2016. The freshwater limpet will be referred to as *Ferrissia bermudensis* throughout the remainder of this Recovery Plan. At present, both species are considered functionally extinct on Bermuda, however field surveys are required before they can formally be declared extinct. Legal protection for *Ferrissia* (syn *Ancylus*) *bermudensis* and *Pisidium volutabundum* is provided by the Protected Species Act (2003) and the Protected Species Amendment Order (2016) which classifies them as Critically Endangered using IUCN red-listing criterion D; (very small or restricted population).

Habitat Requirements and Threats:
Both *Ferrissia bermudensis* and *Pisidium volutabundum* inhabit freshwater wetlands (e.g. ponds, ditches, canals and marshes) and were historically only reported from the Pembroke and Devonshire marshes. Very little is known about the biology and ecology of either species but the main threat is assumed to be the historical alterations made to the both marshes which led to severe habitat loss, fragmentation and degradation. Water pollution may also be a significant, but more modern, threat.

Recovery Objective:
Recovery is dependent on encountering live specimens of either species. Favourable conservation status will be achieved when there is proof that thousands of individuals from both species are found living on Bermuda within stable wetlands that are capable of supporting self-sustaining populations.

Actions Needed:
1. Field surveys to confirm the living status of both species on Bermuda.
2. Initiate recovery actions if live specimens are encountered (i.e. habitat assessments, translocation or aquaculture of molluscs, wetland remediation).
3. If one, or both, species are found to be truly extinct, repatriation of museum specimens from overseas institutions to the collection at the Bermuda Aquarium Museum and Zoo is desirable.

Recovery Costs:
The total cost of recovery actions cannot be defined at this point. Funding needs to be secured through non-governmental organizations (NGO's), overseas agencies, and other interested parties for implementing the necessary research and monitoring studies. Developing budgets for each action are the responsibility of the leading party as outlined in the work plan.

PART I: INTRODUCTION

A. Brief Overview

Ferrissia bermudensis is a very small, freshwater, air-breathing limpet. This endemic limpet was only ever recorded from one location on Bermuda, Pembroke Marsh, where it was recorded as rare by E.G. Vanatta in 1910. *Pisidium volutabundum* is also endemic to Bermuda and was historically recorded from two locations; the Pembroke and Devonshire Marshes. Serious modifications were made to both wetlands during the past 100 years (see Sterrer and Wingate, 1981; Wingate, 1986a; 1986b), including drainage and pollution of the remaining waters. These changes likely impacted the abundance of both species.

In 1996 a comprehensive ecological survey of the entire Pembroke canal from Mill Creek to Glebe Road (including the pond in the east basin) did not find *Ferrissia bermudensis.* Additional surveys undertaken in 2007 and 2008 at 23 different wetlands across Bermuda, including the former range, also failed to find any living specimens of either *Ferrissia bermudensis* or *Pisidium volutabundum.* Both species are believed to have gone extinct.

B. Taxonomy and Description of Species

Kingdom: Animalia
Phylum: Mollusca
Class: Bivalvia
Family: Pisidiidae
Genus: *Pisidium*
Species: *volutabundum*
Common names: Bermuda pea clam, Bermuda fingernail clam

Pisidium is a genus of very small freshwater clams known collectively as the pill, pea, and fingernail clams. Globally, there are at least 12 extant sub-genera and 32 extant species within this genus. The Bermuda pea clam was first described by Edward Guirey Vanatta in 1910. His description is as follows:

"*Shell equivalve, suborbicular, umbones moderately prominent, thin, horn colour, superior margin nearly straight, anterior margin subtruncate, inferior margin arcuate, posterior margin convex. Surface finely striate with irregular lines of growth. Hinge arcuate, narrow, ligament scar concave with a slight longitudinal ridge in the centre. The right valve with one large cardinal and two laterals at each end, the lower ones the largest. The left valve provided with two cardinals the lower recurved and a little anterior, a very heavy lateral at each end of the hinge line, with a deep groove between it and the edge of the shell. Alt. 2.56, diam. 1.73, length 3.13 mm.*"

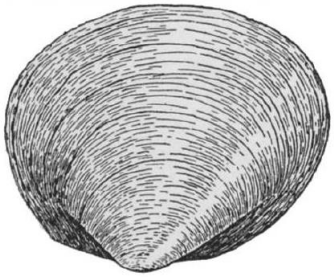

Figure 1. Drawing of the Bermuda pea clam *Pisidium volutabundum*.
Vanatta, 1910

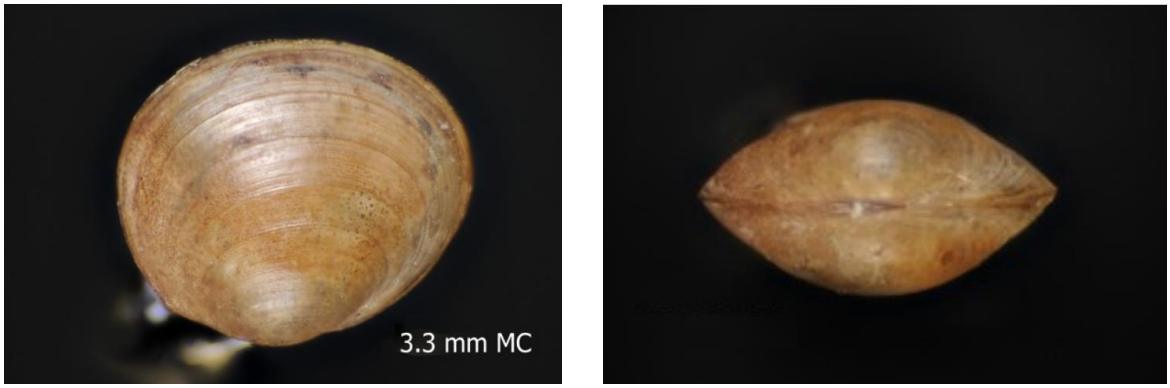

Figure 2. Photographs of the Bermuda pea clam *Pisidium volutabundum*.
From the Academy of Natural Sciences of Philadelphia malacology collection (ANSP#100335)

Kingdom: Animalia
Phylum: Mollusca
Class: Gastropoda
Family: Planorboidae
Genus: *Ferrissia* (formerly *Ancylus*)
Species: *bermudensis*
Common name: Bermuda freshwater limpet

Ferrissia is a genus of very small freshwater limpets. Globally, there are nearly 50 species within this genus. North America's Ancylids were historically assigned to either one of two genera; *Ancylus* or *Gundlachia.* These were subsequently grouped into the subgenus *Ferrissia* by Walker in 1903 and then raised to the full genus level in 1917.

The Bermuda freshwater limpet was first described by E.G. Vanatta under the name *Ancylus bermudensis* in the same 1910 publication as his description of the freshwater pea clam. He described the limpet shell as follows:

"*Oval, greatest width in front, high, thin, horn colour, apex with microscopic radial striae, situated near the posterior right margin, anterior slope convex, posterior and right side concave,*

left side nearly straight. Surface marked with concentric lines of growth and a few obscure radial lines. Alt. .90, diam. 1.73, length 3.10 mm."

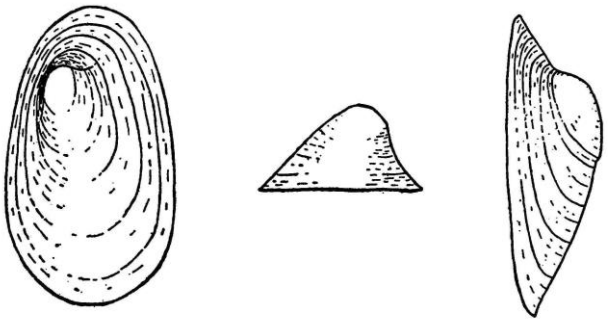

Figure 3. Drawing of the Bermuda limpet *Ferrissia bermudensis*.
Vanatta, 1910

C. Current Status

Global Distribution

Both species are only found on Bermuda.

Local Distribution

Ferrissia bermudensis and *Pisidium volutabundum* were first collected and described from the Pembroke Marsh Basin during the early twentieth century (Vanatta, 1910). Fritz Haas surveyed a number of landlocked ponds on Bermuda between 1947 and 1950 and reported *F. bermudensis* as being rare within the eastern portion of Pembroke Marsh (the western portion having been drained and dried out in 1947) and *P. volutabundum* as being rare within both Pembroke Marsh as well as Devonshire Marsh and its ditches (Haas, 1952). However, Haas mentioned that both marshes were "almost dry" by 1950. More recent surveys have failed to find extant individuals of either species on Bermuda (Thomas, 1996; Williams and Williams, 1998; Outerbridge and Thomas, 2009).

The Pembroke Marsh complex historically extended some two miles inland from Mill Creek, prior to the extensive reclamation activities which took place during the 1920s. It transitioned from a mangrove swamp to a tidal salt marsh and finally to a network of freshwater marshes at the eastern most end. These wetlands covered approximately 120 acres and represented over one third of the total marshland area on Bermuda (Wingate, 1986a). Frequent flooding and persistent mosquitos, which were historically major vectors of human disease, prompted the government to initiate marsh reclamation using landfill. By the end of the 1940s the entire west basin had virtually been reclaimed. The use of east basin of Pembroke Marsh for garbage disposal began during the 1930's when the government started a garbage collection service administered by the Health Department. The growth was accelerated after the mid-1960's when all of the other dumpsites in Bermuda's smaller outlying marsh basins began to be closed following their reclamation, and all of Bermuda's garbage (more than 100 tons a day) was channeled into the Pembroke Marsh site. By 1985 the dump had grown to a huge mound filling the entire eastern end of the marsh basin with its highest points more than 25 feet above marsh level. The relative sterility of the east basin is

owing to the history of reclamation and re-submergence which destroyed the original diversity of peat marsh flora, leaving only cattail and saw-grass (Wingate, 1986b). What remains of the former Pembroke Marsh East Basin is a 19.5 acre Government-owned Nature Reserve, of which approximately 13% comprises open water within a predominantly cattail *Typha augustifolia* and sawgrass *Cladium jamaicense* marshland (Fig. 4). A 1.75 km canal connects Pembroke Marsh East with Mill Creek (the terminal end of the marsh basin); however sections are filled with invasive aquatic plants (e.g. water hyacinth *Eichhornia crassipes* and water lettuce *Pistia stratiotes*) and much of it traverses through industrial land. Salinity ranges from ca. 32 psu (where the canal joins Mill Creek) to >1 psu (water in the marsh) (Boetius and Boetius, 1967).

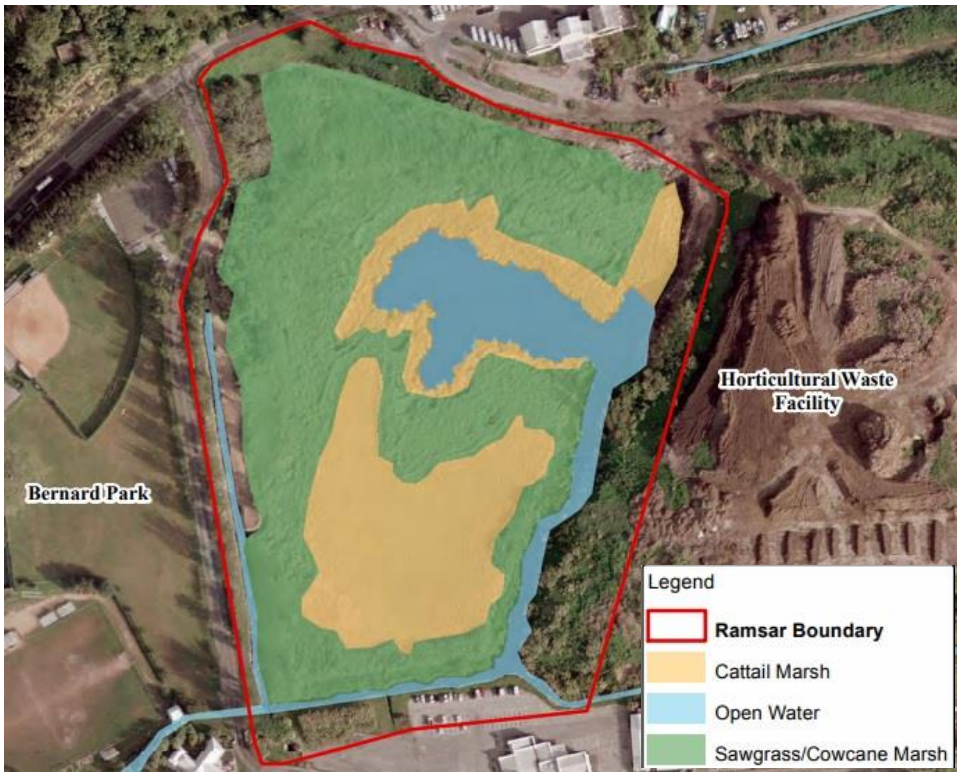

Figure 4. Aerial photograph of Pembroke Marsh East.

Devonshire Marsh (Fig. 5) is Bermuda's largest peat marsh, is situated above Bermuda's largest freshwater lens, and is bisected by Barker's Hill into eastern and western sections. This marshland is almost entirely privately owned, of which nearly 21 acres comprises lands managed by the Bermuda Audubon Society and the Bermuda National Trust (e.g. the Watlington, Winifred Gibbons, Freer Cox, and Firefly Nature Reserves). The marsh was originally a tree-dominated environment (notably cedar and palmetto trees) but a series of large fires from 1914–2018, in conjunction with the scale insect epidemic during the 1940s, windfall during severe hurricanes, and episodic inundation of salt water due to sea level rise has resulted in the loss of the majority of these trees and the transformation to a bracken and grass-dominated landscape (D. Wingate, pers. comm.). A sliver of relatively high, dry land in the Marsh Lane area enabled building for industrial use during the 19th century. An open-water ditch system was created in the 1940s in an attempt to manage mosquitoes and

mosquito-borne diseases and there are still presently a number of ditches and one small pond located within the marsh, all totaling less than one acre in area. The salinity of Devonshire Marsh was reported to be 4 psu in the mid-1980s (Scott and Carbonell, 1986) and only 0.2 psu in the spring of 2017 (A. Copeland, pers. comm.).

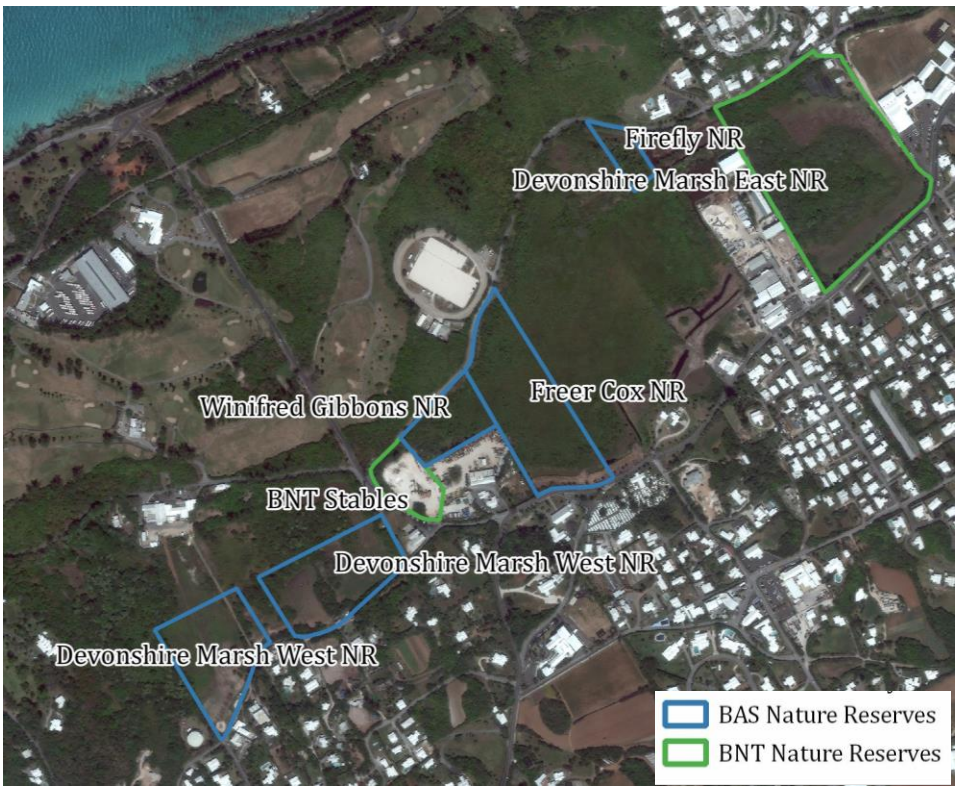

Figure 5. Aerial photograph of Devonshire Marsh.

Species Protection

Legal protection for both is provided by the Protected Species Act (2003). Following IUCN criteria, the Bermuda pea clam *P. volutabundum* and the Bermuda freshwater limpet *F. bermudensis* are both listed as 'Critically Endangered' (D) under the Protected Species Amendment Order (2016). The willful destruction, damage, removal or obstruction of habitats, and the taking, importing, exporting, selling, purchasing, or transporting either of these species an offence. Offenders are liable to a fine of up to $25,000 or two years imprisonment.

Habitat Protection

Pembroke Marsh East is a mixture of Nature Reserve (pond and surrounding grass-dominated marsh), Open Space Reserve (Horticultural Waste Facility) and Recreation. The pond and its associated marsh have also been designated as a Ramsar site which means that it is recognized as a wetland of international importance. The Ramsar Convention is an intergovernmental treaty that provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. Devonshire Marsh is largely zoned Nature Reserve, however it also contains parcels of land zoned as Agricultural Reserve, Open Space Reserve, and Industrial.

D. Ecology

The ecology of *Ferrissia bermudensis* and *Pisidium volutabundum* have not been studied, however it may be inferred from the published accounts of congeneric species:

General biology
Freshwater limpets are very small, air-breathing snails that possess shells which are broadly conical in shape and use a strong muscular foot for locomotion. Pea clams are small, bottom-dwelling bivalves (i.e. body enclosed within a pair of hinged shells) that burrow into soft sediment. They too possess a muscular foot that is used for digging and crawling.

Reproduction
Both the European freshwater limpet *Ancylus fluviatilis* and the North American freshwater limpet *Ferrissia fragilis* are capable of self-fertilization (Stadler et al., 1995). Eggs are ca. 0.6 mm in diameter and broadcast individually into the water (Dillon and Herman, 2009). Pea clams are also hermaphroditic, but ovoviviparous; fertilization is internal and the young hatch from eggs within the parental body before emerging (Martin, 1998). An adult clam may contain up to 60 young in various stages of development, depending on the species (Pennak, 1989).

Life Cycle
Generation times of less than six weeks have been reported in laboratory populations of *F. fragilis*, with adults maturing at around 2-3 mm shell length (Dillon and Herman, 2009). Jokinen (1985) reported three generations per year for an *F. fragilis* population in Connecticut. Fingernail and pea clams have been reported to live between 1-4 years (Martin, 1998).

Diet
Freshwater limpets are generally found to be grazers, with diets especially rich in diatoms (Dillon, 2000), so it is reasonable to presume that *Ferrissia bermudensis* feeds upon algae. Pea clams are filter feeders that extract organic material from the water column.

Habitat Requirements
Ferrissia fragilis, a very common North American freshwater limpet, inhabits a variety of aquatic habitats (i.e. streams, rivers, lakes, ponds) on rocks, woody debris, macrophytes and dead leaves. Dillion and Herman (2009) reported *F. fragilis* as being 'common in the swamps and ditches of the coastal plains' in South Carolina. Adequate levels of dissolved oxygen seem to be necessary for survival, therefore the species is not typically found in warm, stagnant waters or within environments that are severely polluted. *Ancylus fluviatilis* (a freshwater limpet found throughout Europe) is reported to prefer inhabiting cold, fast flowing rivers generally on rock substrate as well as in some lake littorals with high wave energy (Durrant, 1977). Abundance has been reported to be between 15 and 30 limpets per square meter (Durrant, 1980) and up to 234 pea clams per square meter (Hamill et al., 1979).

Pisidium pea clams typically inhabit sandy or gravel bottoms in large rivers and shallow lakes as well as well-oxygenated creeks and ponds; however some species are known to attach to the roots and stems of underwater aquatic plants. Adequate water movement is needed to ensure a continual supply of oxygen and food (Thorp and Rogers, 2011).

Pea clams and freshwater limpets are reported to be intolerant to changes in water chemistry and temperature. The maximum salinity tolerance for five species of European pea clams belonging to the genus *Pisidium* was reported to range 0.5 – 3.5 ppt; for the European limpet *Ancylus fluviatilis* it was reported to be 4 ppt; and for *Ferrissia wauteri* it was only 1 ppt (Verbrugge et al., 2012). Maximum water temperature tolerances ranged from 30-33°C (Verbrugge et al., 2012).

E. Current Threats

Threats to the survival of both *Ferrissia bermudensis* and *Pisidium volutabundum* are presumed to be habitat degradation through development and pollution.

Habitat loss

Freshwater marshes across Bermuda have been greatly reduced in area as a consequence of development and land reclamation. Since Bermuda's permanent settlement from 1612 onwards, humans have filled, drained, denuded, and polluted the mangrove swamps, ponds, and inland marshes in an effort to create more arable land, residential and commercial building sites, eliminate mosquitos, and to dispose of unwanted waste material. Records indicate that at the beginning of the 20th century approximately 169.2 ha, or roughly 3% of Bermuda's total land area, comprised wetlands which included 20.4 ha of mangrove swamp, 29.6 ha of ponds and 119.2 ha of inland marsh. By 1980, these wetland areas had been reduced to an estimated 94.3 ha (16.7 ha of mangrove swamp, 29.2 ha of ponds, and 48.4 ha of inland marsh), representing a decrease of 44.5% (Sterrer and Wingate, 1981) and contributing to major losses of biodiversity in those areas (Sterrer, 1998; Sterrer et al., 2004). Furthermore, widespread drainage of the inland marshes was employed as part of the mosquito control methods in the first half of the 20th century, as health officials attempted to prevent the spread of mosquito borne diseases. During the period when the most intensive efforts were being made towards marsh reclamation by the Bermuda Government - who had assumed the responsibility for garbage collection and a policy of disposing it in the wetlands - nearly 60% of the inland marsh habitat was lost and at least five ponds were completely filled in (Sterrer and Wingate, 1981).

Pollution

What remains of eastern portion of Pembroke Marsh is situated immediately adjacent to the former Marsh Folly dump site where municipal solid waste was disposed of between the 1930s and 1990s. Hydrogeological studies in the 1980s indicated that the peat layer beneath Pembroke Marsh acts as an impermeable seal between the dump and the surrounding bedrock, thus polluted leachate from the dump tends to drain into the surface water of Pembroke Pond and out to sea via Pembroke Canal, rather than contaminating the groundwater within the rock (Wingate 1986b). Thomas (1996) reported very high levels of faecal coliform bacteria throughout the canal and visible oil pollution between Cemetery Road and Mill Creek. During much of the 20th century, garbage was dumped in marshes and ponds across Bermuda (Sterrer and Wingate, 1981). Although not industrialised, Bermuda is characterised by high levels of localised anthropogenic pollution (Jones, 2011). Recent investigations of the health status of the pond environment on Bermuda suggest that there is a suite of contaminants of concern that are having detrimental effects on the resident fauna. Tissue residue analyses from a range of taxa, including cane toads *Rhinella marinus*, mosquitofish *Gambusia holbrooki*, killifish *Fundulus* spp., and red-eared sliders *Trachemys*

scripta elegans collected from a variety of contaminated wetlands across Bermuda have shown that petroleum hydrocarbons, polycyclic aromatic hydrocarbons and trace metals are being accumulated and induce developmental malformations, endocrine disruption, liver and gonad abnormalities plus immunological stress (Fort et al., 2006; Fort et al., 2006; Bacon, 2010; Bacon et al., 2012). Entry of contaminants into the wetlands comes through storm-water run-off from adjacent roadways, car parks and house drives, aerial deposition and leachate from nearby landfills and ground-water sources (Fort et al., 2006). More recent investigations revealed that some of Bermuda's aquatic gastropods showed elevated levels of trace metals (e.g. arsenic, cadmium, chromium, copper, iron, lead, nickel, zinc and mercury) as well as organic pollutants (Outerbridge et al., 2015).

Aquatic animals
Gale (1973) reported that fingernail and pea clams are regularly eaten by a variety of aquatic birds and bottom-feeding fishes. There are a number of native and non-native aquatic species presently inhabiting the Pembroke and Devonshire Marshes (e.g. apple snails *Pomacea sp*., eastern mosquitofish *Gambusia holbrooki,* red-eared sliders *Trachemys scripta elegans,* and numerous species of water birds), but it is unclear if any pose a threat to the limpets or the pea clams through either predation or grazing competition.

F. Current Conservation Action

No conservation actions are currently taking place for these species.

The Bermuda Natural History Museum does not have any specimens of either species in the wet or dry collections, therefore the return of specimens from overseas natural history collections to Bermuda's museum is desirable.

PART II: RECOVERY

A. Recovery Goals

Recovery is dependent on encountering live specimens of either species.

B. Recovery Objectives and Criteria

Favourable conservation status will be considered when there is proof that thousands of molluscs from both species are found living on Bermuda within stable wetlands that are capable of supporting self-sustaining populations.

These overall objectives translate into specific targets outlined below:

1. Field surveys to confirm the living status of both species on Bermuda.
2. Initiate recovery actions if live specimens are encountered (i.e. habitat assessments, translocation or aquaculture of molluscs, wetland remediation).
3. If one, or both, species are found to be truly extinct, repatriation of museum specimens from overseas institutions to the collection at the Bermuda Aquarium Museum and Zoo is desirable.

C. Recovery Strategy

Given that recovery is contingent on locating living specimens, field surveys should be given first priority. If live molluscs are encountered, the next step should be to assess the physical characteristics (i.e. seasonal temperature and salinity fluctuations; levels of contamination) of all of Bermuda's freshwater wetlands. This information can then be compared to the environmental parameters of the body of water inhabited by the living specimens and used to help inform future translocations or introductions. Wetland remediation activities may be needed to reduce the level of contamination in the ponds, especially within the benthic sediment. Only after suitable locations have been identified can the transferal of molluscs occur, either through the direct collection and immediate transfer of individuals (if the founding population is deemed to be robust) or through collection and propagation via aquaculture. The multi-species fish hatchery on the Coney Island field station could be used for this purpose. Periodic monitoring of the newly established sub-populations will be required in order to determine short-term and longer-term founding success. If the local populations are ultimately considered extirpated, no further conservation action will be necessary and de-listing from the Protected Species Order should be considered.

D. Tools Available for Strategy

Wetland remediation

Examples of wetland remediation include phytoremediation, in which plants are used to extract persistent contaminants from surrounding substrate, as well as employing various chemical and biological remediation techniques. Chemical remediation methods include reducing or eliminating inputs of contaminants from point sources, natural sediment remediation by biodegradation and chemical degradation, and active sediment remediation by removal or by in situ treatment; biological remediation methods include enhancing populations of target organisms (see reviews in Wilcox and Whillans, 1999). Some wetland plants have been shown to sequester petroleum hydrocarbons (Lin and Mendelssohn, 1998), polycyclic aromatic hydrocarbons (Lin and Mendelssohn, 2009) and trace metals (Weis and Weis, 2004) from wetland sediment and store them below ground in roots or concentrate them in aerial tissues (e.g. leaves and stems). Depositing clean sediment (e.g. diatomaceous earth) over contaminated sediment is yet another technique of wetland remediation that can diminish the risk of biological contact, however it should not be considered without first assessing its impact on the water column and aquatic biota of the ponds. Additionally, the creation of buffer zones between road drains and freshwater wetlands would help to reduce direct in-put of pollutants by serving as a filter for contaminants entering as road runoff. Introduction of oxygenated air into the organic sediment of contaminated areas promotes natural biological degradation of some contaminants (e.g. polycyclic aromatic hydrocarbons) by increasing the activity of indigenous bacteria that are capable of metabolizing pollutants (D. Fort, personal communication). This has been recently trialed in some of Bermuda's wetlands and appears to significantly reduce the level of polycyclic aromatic hydrocarbons after one year (J. Bacon, pers. comm.).

Aquaculture

The North American ancylid limpets *Ferrissia rivularis* and *Ferrissia fragilis* can be reared from egg to adulthood under controlled conditions in the laboratory. Dillon and Herman (2009) provide a summary of culture techniques, and reported that eggs took one week to hatch and an additional four to five weeks for individuals to reach maturation. Fingernail and pea clams have also been raised under laboratory conditions (see Krull, 1936; Thomas, 1954).

E. Step-down Narrative of Work Plan

Abbreviations used in Section E and Part III:

DENR – Department of Environment and Natural Resources
Parks – Department of Parks
BAS – Bermuda Audubon Society
BNT – Bermuda National Trust

The actions needed to achieve recovery are as follows:

1. Perform surveys to confirm the living status of both species on Bermuda.

Actions proposed:

- Undertake field surveys in Devonshire Marsh and within Pembroke Marsh East, paying particular attention to rooted vegetation, floating vegetation, and submerged rocks.

Work Team: DENR
Assistance: Student volunteers or volunteers from the general public.
Outputs: Report on the survey results.

2. Initiate recovery actions if live specimens are encountered (i.e. habitat assessments, translocation or aquaculture of molluscs, wetland remediation).

Actions proposed:

- Assess the physical characteristics of Bermuda's freshwater wetlands,
- Select sites identified as being suitable for species survival,
- Habitat restoration (remediation and the control of invasive species),
- Translocate (if donor populations are robust enough to tolerate collection),
- Aquaculture (if donor populations are not robust),
- Monitor newly established sub-populations,
- Manage relict wild sub-population(s),
- Identify threats to survival and mitigate as much as possible.

Work Team: DENR, landowners including NGOs such as Bermuda National Trust and Bermuda Audubon Society, Parks Department.
Team Leader: DENR
Assistance: NGO's that own and manage protected freshwater wetlands.
Outputs: Increased habitat availability for species, expanded island wide distribution of species, report on growth and survival assessing habitat adequacy.

3. If one, or both, species are found to be truly extinct, repatriation of museum specimens from overseas institutions to the collection at the Bermuda Aquarium Museum and Zoo is desirable.

Actions proposed:

- Contact the curators of the various malacology collections in the USA (e.g. the Academy of Natural Sciences in Philadelphia) and ask if some specimens can be donated,
- Accession into the BAMZ Natural History collection.

Work Team: DENR
Team Leader: Curator of Natural History Museum at BAMZ.
Assistance: Overseas collections.
Outputs: Addition of new museum specimens into the Bermuda collection.

F. Estimated Date of Down Listing

Freshwater limpets and pea clams are capable of rapid growth in a short time frame, therefore it should be possible to consider down listing their status within 3-5 years, provided the above recovery actions are successful.

PART III: IMPLEMENTATION

Priority 1: An action that must be taken to prevent extinction or to prevent the species from declining irreversibly.
Priority 2: An action that must be taken to prevent a significant decline in the species population/habitat quality, or some other significant negative impact short of extinction.
Priority 3: All other action necessary to provide for full recovery of the species.

Priority #	Task #	Task description	Task Duration	Responsible Party
1		**Surveys to confirm the status of both species on Bermuda**		DENR
	1	Undertake field surveys	3 months	DENR, volunteers
2		**Initiate recovery actions if live specimens are encountered**		DENR
	2	Assess physical characteristics of fresh water ponds	Min. 12 months to understand seasonal variance	DENR, volunteers
	3	Select sites for translocation	1 month	DENR, NGOs
	4	Habitat restoration	12 months	DENR, NGOs
	5	Translocate/propagate	1-3 months	DENR, volunteers
	6	Monitor	ongoing	DENR, volunteers
	7	Manage	ongoing	DENR, NGOs
	8	Identify threats to survival	Ongoing	DENR
3		**Repatriation of museum specimens**		DENR
	9	Contact and ask overseas institutions	1 month	Museum curator at BAMZ
	10	Accession into Bermuda collection	1-3 months	Museum curator at BAMZ

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