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Candidate Petition Project

CRUSTACEANS

PETITIONS TO LIST AS FEDERALLY ENDANGERED SPECIES

The following document contains the individual petitions for the 8 crustacean species to be listed as federally endangered species under the federal Endangered Species Act.

Camp Shelby burrowing crayfish

Anchialine pool shrimp

Anchialine pool shrimp

Anchialine pool shrimp

Anchialine pool shrimp

Anchialine pool shrimp

Anchialine pool shrimp

Troglobitic groundwater shrimp

Fallicambarus gordonii

Antecaridina lauensis

Calliasmata pholidota

Metabetaeus lohena

Palaemonella burnsi

Procaris hawaiiiana

Vetericaris chaceorum

Typhlatya monae

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PETITION TO LIST

Camp Shelby burrowing crayfish (*Fallicambarus gordonii*)

AS A FEDERALLY ENDANGERED SPECIES

CANDIDATE HISTORY

CNOR 11/21/91:
CNOR 11/15/94:
CNOR 10/25/99: C
CNOR 10/30/01: C
CNOR 6/13/02: C

TAXONOMY

The Camp Shelby burrowing crayfish, *Fallicambarus gordonii* (Cambaridae), was described in 1987 from southeast Mississippi (Fitzpatrick 1987).

NATURAL HISTORY

The Camp Shelby burrowing crayfish (CSBC) is a small burrowing crayfish less than 30 millimeters (1.5 inches) in length. It is distinguished from closely related species by a broader rostrum, characters of the chela, and characters of the male and female sexual organs.

The CSBC is a short-lived (2 to 3 years) burrowing crayfish that estivates during dry summer months, and is active during late fall, winter, and spring (Johnson and Figiel 1997). Reproductively active males (Form I) are found throughout this activity period. Females bearing eggs have only been collected during late fall and early winter. Egg numbers range from 7 to 25 per female. Juveniles are present during most of the year, but are more frequently collected in the late spring. Burrows consist of a shallow oval chamber with one to four openings. Concentrations of burrows are found only in pitcher plant bogs. Observations on the distribution of the species indicate that the CSBC is dependent on the maintenance of open-bog habitats for survival (Johnson and Figiel 1997). The species is found in association with flat woodland pitcher plant wetlands, locally referred to as pitcher plant bogs.

Extensive crayfish surveys of pitcher plant wetlands in southern Mississippi and Alabama have documented the CSBC only from a small area in central Perry County, Mississippi (Fitzpatrick 1987, 1991).

POPULATION STATUS

CSBC are locally common in the small pitcher plant bogs where they occur. To date, 18 pitcher plant wetlands in central Perry County, Mississippi have been found supporting a total of fewer than 3,000 individuals of the species (*in litt.* 1999 cited in U.S. Fish and Wildlife Service candidate assessment form).

The Mississippi Natural Heritage Program ranks the Camp Shelby burrowing crayfish as Critically Imperiled.

The U.S. Fish and Wildlife Service classifies the Camp Shelby burrowing crayfish as a candidate for Endangered Species Act protection with a listing priority number of 11.

LISTING CRITERIA

A. The present or threatened destruction, modification, or curtailment of its habitat or range.

Historical range: Perry County, Mississippi.

Current range: Perry County, Mississippi.

Land ownership: All known habitat for the species occurs on U.S. Forest Service lands leased by the U.S. Army National Guard.

The CSBC is believed to be naturally limited in range. It is found only on pitcher plant wetlands on U.S. Forest Service (USFS) lands leased by the U.S. Army National Guard's (NG) Camp Shelby for troop and tank training grounds. All pitcher plant wetlands combined comprise less than 500 acres of Camp Shelby's 135,000 acres, and the crayfish has been associated with only a few of these (*in litt.* 1999 cited in U.S. Fish and Wildlife Service candidate assessment form).

The CSBC is vulnerable to activities that would directly destroy its burrows, compact the soil, or alter the hydrology of its flat pine woodland wetland habitat. The primary activities occurring in areas surrounding CSBC habitat include silvicultural activities by the USFS and tank and troop maneuvers by the NG. Silvicultural activities that could harm the species include canopy removal and dessication, soil compaction and rutting from heavy equipment operation, and toxic runoff from pesticide and herbicide applications. NG troop and tank maneuvers within crayfish habitat can kill or entomb animals, compact the soil, and/or affect hydrology through rutting.

B. Overutilization for commercial, recreational, scientific, or educational purposes.

CSBCs are not utilized for commercial or recreational purposes. Their cryptic habits protect them from overzealous scientific collection.

C. Disease or predation.

Diseases affecting the CSBC are unknown. Although a number of vertebrate predators are known to prey on crayfish, natural predation does not appear to be a threat.

D. The inadequacy of existing regulatory mechanisms.

The species is not currently protected under other environmental laws and regulations.

Current Conservation Efforts: The Forest Service and National Guard are aware of the locations inhabited by the CSBC and its vulnerability to their activities. Surveys and life history studies have been conducted. The Mississippi Natural Heritage Program and The Nature Conservancy have been monitoring the species and its habitat in cooperation with the National Guard and Forest Service. The Forest Service and National Guard have been cooperative in working with the State to avoid impacts. The National Guard has requested Mississippi Field Office assistance in developing and entering into a Candidate Conservation Agreement that will reduce or remove all known significant threats to the CSBC.

E. Other natural or manmade factors affecting its continued existence.

All Terrain Vehicle (ATV) use is high in the area where the CSBC occurs. ATV trails have been observed through pitcher plant bogs inhabited by CSBC. ATV use in these areas may result in direct mortality to CSBC.

REFERENCES

Fitzpatrick, J.P. 1987. *Fallicambarus burrisi* and *F. gordonii*, two new burrowing crayfishes associated with pitcher plant bogs in Mississippi and Alabama. Proceedings of the Biological Society of Washington 100:433-446.

Fitzpatrick, J.P. 1991. Status survey report Camp Shelby crayfish. Report to U.S. Army Corps of Engineers, Champaign, Illinois. Pp. 1-14.

Johnston, C.E. and C. Figiel. 1997. Microhabitat parameters and life-history characteristics of *Fallicambarus gordonii* Fitzpatrick, a crayfish associated with pitcher-plant bogs in southern Mississippi. Journal of Crustacean Biology 17(4):687-691.

PETITION TO LIST

anchialine pool shrimp
(*Antecaridina lauensis*)

AS A FEDERALLY ENDANGERED SPECIES

CANDIDATE HISTORY

CNOR 1/6/89:

CNOR 11/21/91:

CNOR 11/15/94:

CNOR 10/25/99: C

CNOR 10/30/01: C

CNOR 6/13/02: C

TAXONOMY

The taxonomic status of *Antecaridina lauensis* (Atyidae) as a valid species is uncontroversial (e.g., Bishop Museum 2001).

NATURAL HISTORY

Antecaridina lauensis (Holthuis 1973) is reported to range from 10 millimeters (mm) (0.40 inches (in)) to just over 15 mm (0.60 in) in total length. The thorax, abdomen, mouthparts, and legs are red. In other parts of its geographic distribution (e.g., the Red Sea) this species has been documented to be present in a range of colors, from red to transparent. The relatively small chelae (claws) are whitish. Black pigments are associated with the eyes. *A. lauensis* moves about by walking over the substrate. Observations suggest that this species is herbivorous and most active by night (Holthuis 1973).

Within the Hawaiian Islands, *Antecaridina lauensis* is known to occur in low- to high-salinity (2-30 parts per thousand (ppt)) anchialine pools. Anchialine pools are land-locked bodies of water that occur coastally but are not openly connected to the ocean (Maciolek 1983). They are mixohaline, with salinities typically ranging from 2 ppt to concentrations to just below that of sea water (32 ppt), although there are pools recorded as having salinities as high as 41 ppt (Maciolek 1983).

Anchialine pools are subject to tidal fluctuations. Except for some records of endemic eels, anchialine pools in Hawaii do not support native species of fish, although some species of alien

fish have been introduced and are currently recognized as problems (see below). Anchialine pools are very limited in number and the total area occupied by them globally is extremely small.

While a number of species of anchialine shrimp (e.g., *Antecaridina lauensis*, *Calliasmata pholidota*) have disjunct, global distributions within these habitats, most geographic locations contain some endemic taxa. In the state of Hawaii, there are estimated to be over 650 anchialine pools, with an estimated 90 percent of these occurring on the island of Hawaii. Unfortunately, approximately 90 percent of the pools on that island have been destroyed or otherwise impacted by development or other human uses (personal communication 1998 cited in U.S. Fish and Wildlife Service candidate assessment form).

Antecaridina lauensis has a disjunct, Indo-Pacific distribution, as it has been reported from locations as distant as the Red Sea, islands near Madagascar, the Ryukyu Islands, and the Hawaiian Islands.

POPULATION STATUS

In Hawaii, *A. lauensis* is known from two pools in the Cape Kinau area (Maui) and two pools on the southern end of Hawaii Island. While no population estimates are available, only a few individuals are reported to have been seen or collected from the four documented locations in Hawaii. Population numbers and numbers of individuals outside the U.S. are unknown.

The Hawaii Natural Heritage Program ranks *Antecaridina lauensis* as Critically Imperiled.

The U.S. Fish and Wildlife Service classifies *Antecaridina lauensis* as a candidate for Endangered Species Act protection with a listing priority number of 2.

LISTING CRITERIA

A. The present or threatened destruction, modification, or curtailment of its habitat or range.

Historical range: Within the U.S., *Antecaridina lauensis* occurs on the Hawaiian Islands of Maui and Hawaii. This species has also been reported from Fiji, Europa Island (Mozambique), Dahlack (Saudi Arabia), Daito Islands and Ryukyu Islands (Japan), and the Solomon Islands.

Current range: Hawaii (islands of Maui and Hawaii), Europa Island (Mozambique), Dahlack (Saudi Arabia), Daito Islands and Ryukyu Islands (Japan).

Land ownership: In Hawaii, the four anchialine pools known to contain *Antecaridina lauensis* occur on State and private lands.

On the island of Hawaii up to 90 percent of the anchialine pools are estimated to have been destroyed or altered by human activities (personal communication 1998 cited in U.S. Fish and

Wildlife Service candidate assessment form). Introduction of alien fish or bait-fish into such pools may be a major contribution to the decline of these shrimp (see below). Although the two known Maui pools, containing *A. lauensis* occur within a protected state reserve, habitat modifications by early Hawaiians and later inhabitants have occurred in the area. Dumping of refuse and the introduction of alien fish threaten the known populations on the island of Hawaii and have impacted other anchialine pools on that island (*in litt.* 1985 cited in U.S. Fish and Wildlife Service candidate assessment form). The second location on the island of Hawaii is on private land and its status is not currently known. Damage from use of anchialine pools for swimming and bathing has been documented in the Hawaiian Islands (*in litt.* 1985 cited in U.S. Fish and Wildlife Service candidate assessment form). However, this is not believed to be a serious problem in the Maui pools where *A. lauensis* is reported to occur. Such impacts to the Hawaii Island pools are possible but have not, at present, been documented. The status of occupied habitats outside the U.S. is not known.

B. Overutilization for commercial, recreational, scientific, or educational purposes.

Not applicable.

C. Disease or predation.

In Hawaii, predation by alien fish is considered to be the greatest threat to native shrimp within intact anchialine pool ecosystems (Bailey-Brock and Brock 1993; personal communication 1998 cited in U.S. Fish and Wildlife Service candidate assessment form). Anchialine pools have been used to discard or hold bait- fish and/or aquarium fish (Bailey-Brock and Brock 1993). These fish either directly consume the native shrimp or, as with introduced tilapia (*Oreochromis mossambica*), out-compete the native herbivorous species of shrimp which typically serve as the prey-base for the rarer, predatory species of shrimp. Information on threats from disease or predation outside the U.S. is not available.

D. The inadequacy of existing regulatory mechanisms.

The two Maui pools are located on a State natural area reserve, thus receiving some degree of protection. One Hawaii Island pool occurs on lands managed by a different State agency and is not afforded protection, while a second pool is located on unprotected, remote private land. Protection measures for *A. lauensis* outside the U.S. are unknown.

Current Conservation Efforts: In Hawaii, two of the known pools containing *A. lauensis* lie within a State natural area reserve. The rarity of this and other native species of shrimp contributed to the current protection received by the Maui anchialine pools (Holthuis 1973). No conservation agreements between Federal, State, or private landowners have been drafted or initiated for this species and, aside from placement of some pools within reserves, virtually no conservation activities have been conducted.

E. Other natural or manmade factors affecting its continued existence.

In Hawaii, the two Maui pools occur in areas that were volcanically active as little as 250 years ago. The anchialine pool on State land on the island of Hawaii occurs in an area that could be destroyed by on-going volcanic or land subsidence events. However, neither of these pose an imminent threat.

REFERENCES

- Bailey-Brock, J.H. and R.E. Brock. 1993. Feeding, reproduction, and sense organs of the Hawaiian anchialine shrimp *Halocaridina rubra* (Atyidae). *Pacific Science* 47:338-355.
- Bishop Museum of Honolulu. Checklist of Marine Invertebrates of the Hawaiian Islands, revised 29 January 2001. (<http://www2.bishopmuseum.org/HBS/invert/search.asp>)
- Holthuis, L.B. 1973. Caridean shrimps found in land-locked saltwater pools at four Indo-west Pacific localities (Sinai Peninsula, Funafuti Atoll, Maui and Hawaii Islands), with the description of one new genus and four new species. *Zool. Verhadenlingen* 128: 3-55.
- Maciolek, J.A. 1983. Distribution and biology of Indo-pacific insular hypogeal shrimps. *Bulletin of Marine Science* 33:606- 618.

PETITION TO LIST

anchialine pool shrimp (*Calliasmata pholidota*)

AS A FEDERALLY ENDANGERED SPECIES

CANDIDATE HISTORY

CNOR 1/6/89:

CNOR 11/21/91:

CNOR 11/15/94:

CNOR 10/25/99: C

CNOR 10/30/01: C

CNOR 6/13/02: C

TAXONOMY

The taxonomic status of *Calliasmata pholidota* (Hippolytidae) as a valid species is uncontroversial (e.g., Bishop Museum 2001). In its candidate species list, the U.S. Fish and Wildlife Service lists this species in the family Alpheidae.

NATURAL HISTORY

Calliasmata pholidota (Holthuis 1973) is reported to range from 15 millimeters (mm) (0.60 inches (in)) to just over 30 mm (1.18 in) in total length. Typically, the body color is pale pink to brilliant red (with red banding); legs are red to pale. There is frequently a traverse red band along the base of the telson (tail). Shrimps can change the intensity of the red pigment. Black pigments are associated with the eyes. Chelae (claws) are conspicuous. This shrimp moves about by walking over the substrate. Observations suggest that *C. pholidota* are opportunistic, taking live prey or scavenging (Maciolek in Holthuis 1973).

Within the Hawaiian Islands, *Calliasamata pholidota* is known to occur in mid- to high-salinity (19-30 parts per thousand (ppt)) anchialine pools. Anchialine pools are land-locked bodies of water that occur coastally but are not openly connected to the ocean (Maciolek 1983). They are mixohaline, with salinities typically ranging from 2 ppt to concentrations just below that of sea water (32 ppt), although there are pools recorded as having salinities as high as 41 ppt (Maciolek 1983). Anchialine pools are subject to tidal fluctuations. Except for some records of endemic eels, anchialine pools in Hawaii do not support native species of fish, although some species of alien fish have been introduced and are currently recognized as problems (see below).

Anchialine pools are very limited in number and the total area occupied by them globally is extremely small.

While a number of species of anchialine shrimp (e.g., *Anticardina lauensis*, *Calliasmata pholidota*) have disjunct, global distributions within these habitats, most geographic locations contain some endemic taxa. In the state of Hawaii, there are estimated to be over 650 anchialine pools, with an estimated 90 percent of these occurring on the island of Hawaii. Unfortunately, approximately 90 percent of the pools on that island have been destroyed or otherwise impacted by development or other human uses (personal communication 1998 cited in U.S. Fish and Wildlife Service candidate assessment form.

Calliasmata pholidota has a disjunct, Indo-Pacific distribution, as it has been reported from a single location at the southern tip of the Sinai Peninsula (which is in Egypt, not in Saudi Arabia as is mistakenly indicated in the candidate assessment form for this species and in the published candidate species list), a single location on Funafuti Atoll (Tuvalu Islands), and two locations in the Hawaiian Islands, Hawaii (a single pool) and Maui (6 pools). In Hawaii, *Calliasmata pholidota* has never been found to be abundant.

POPULATION STATUS

Maciolek (in Holthuis 1973) states that the total population number of *C. pholidota* in one pool on Maui was “no more than a couple dozen.” Given that this species is only known from seven pools in the entire state, its numbers in Hawaii are assumed to be small. Population numbers and numbers of individuals outside the U.S. are unknown.

The U.S. Fish and Wildlife Service classifies *Calliasmata pholidota* as a candidate for Endangered Species Act protection with a listing priority number of 2.

LISTING CRITERIA

A. The present or threatened destruction, modification, or curtailment of its habitat or range.

Historical range: Within the U.S., *Calliasmata pholidota* occurs on the Hawaiian Islands of Maui and Hawaii. This species has also been reported from Tuvalu and from the Sinai Peninsula.

Current range: Hawaii (islands of Hawaii and Maui); Tuvalu (Funafuti Atoll); Sinai Peninsula.

Land ownership: In Hawaii, the seven anchialine pools known to contain *Calliasmata pholidota* occur on State land. The six Maui pools are located on a natural area reserve, thus receiving some degree of protection. The Hawaii Island pool occurs on land managed by a different State agency and is not afforded protection.

On the island of Hawaii up to 90 percent of the anchialine pools have been destroyed or altered by human activities (personal communication 1998 cited in U.S. Fish and Wildlife Service candidate assessment form). Introduction of alien fish or bait-fish into such pools may be a major contribution to the decline of these shrimp (see below). Although the six known Maui pools containing *Callinectes sapidus* occur within a protected state reserve, habitat modifications by early Hawaiians and later inhabitants have occurred in the area. Dumping of refuse and the introduction of alien fish threaten the known populations on the island of Hawaii. Damage from use of anchialine pools for swimming and bathing has been documented in the Hawaiian Islands (*in litt.* 1985 cited in U.S. Fish and Wildlife Service candidate assessment form). However, this is not believed to be a serious problem in the Maui pools where *Callinectes sapidus* occurs. Such impacts to the pool on the island of Hawaii are possible but have not, at present, been documented. The status of occupied habitats outside the U.S. is not known.

B. *Overutilization for commercial, recreational, scientific, or educational purposes.*

Not applicable.

C. *Disease or predation.*

In Hawaii, predation is considered to be the greatest threat to intact anchialine pool ecosystems (Bailey-Brock and Brock 1993; personal communication 1998 cited in U.S. Fish and Wildlife Service candidate assessment form). Anchialine pools have been used to discard or hold bait-fish and/or aquarium fish (Bailey- Brock and Brock 1993). These fish either directly consume the native shrimp or, as with introduced tilapia (*Oreochromis mossambica*), out-compete the native herbivorous species of shrimp which typically serve as the prey-base for the rarer, predatory species of shrimp. Information on threats from disease or predation outside the U.S. is not available.

D. *The inadequacy of existing regulatory mechanisms.*

No current protection.

Current Conservation Efforts: In Hawaii, six of the known pools containing *Callinectes sapidus* lie within a state natural area reserve. The rarity of this shrimp contributed to the current protection received by the Maui anchialine pools (Holthuis 1973). No conservation agreements between Federal, State, or private landowners have been drafted or initiated and, aside from placement of some pools within reserves, virtually no conservation activities have been conducted. The Sinai Peninsula population is represented in a single anchialine pool which has been fenced and posted for protective measures.

E. *Other natural or manmade factors affecting its continued existence.*

In Hawaii, the Maui population(s) occur in areas that were volcanically active as little as 250 years ago. The anchialine pool on the island of Hawaii that contains *Callinectes sapidus*

occurs in an area that could be destroyed by on-going volcanic or land subsidence events. However, neither of these pose an imminent threat.

REFERENCES

- Bailey-Brock, J.H. and R.E. Brock. 1993. Feeding, reproduction, and sense organs of the Hawaiian anchialine shrimp *Halocaridina rubra* (Atyidae). *Pacific Science* 47: 338-355.
- Bishop Museum of Honolulu. Checklist of Marine Invertebrates of the Hawaiian Islands, revised 29 January 2001. (<http://www2.bishopmuseum.org/HBS/invert/search.asp>)
- Holthuis, L.B. 1973. Caridean shrimps found in land-locked saltwater pools at four Indo-west Pacific localities (Sinai Peninsula, Funafuti Atoll, Maui and Hawaii Islands), with the description of one new genus and four new species. *Zool. Verhadenlingen* 128: 3-55.
- Maciolek, J.A. 1983. Distribution and biology of Indo-pacific insular hypogeal shrimps. *Bulletin of Marine Science* 33: 606-618.

PETITION TO LIST

anchialine pool shrimp (*Metabetaeus lohena*)

AS A FEDERALLY ENDANGERED SPECIES

CANDIDATE HISTORY

CNOR 1/6/89:

CNOR 11/15/94:

CNOR 10/25/99: C

CNOR 10/30/01: C

CNOR 6/13/02: C

TAXONOMY

The taxonomic status of *Metabetaeus lohena* (Alpheidae) as a valid species is uncontroversial (e.g., Bishop Museum 2001).

NATURAL HISTORY

Metabetaeus lohena grows up to 18 millimeters (mm)(0.71 inches (in)) long. Its body coloration ranges from pale-pink to brilliant red, with a conspicuous mandibular spot (Banner and Banner 1960). Chelae (claws) are relatively large and conspicuous.

These shrimp move about by crawling along the substrate. They are primarily predators, feeding largely on the more common anchialine pool shrimp *Halocaridina rubra* (Holthuis 1973). However, as with most decapods, they may occasionally scavenge.

Metabetaeus lohena is known to occur in both low and high salinity anchialine pools on the Hawaiian islands of Maui and Hawaii, and possibly on Oahu. Anchialine pools are land-locked bodies of water that occur coastally but are not openly connected to the ocean. They are mixohaline, with salinities ranging from 2 parts per thousand (ppt) to concentrations just below that of sea water (32 ppt) (Maciolek 1983). Anchialine pools are subject to tidal fluctuations.

Except for some records of endemic eels, anchialine pools in Hawaii do not support native species of fish, although some species of alien fish have been introduced and are currently recognized as problems (see below).

Although anchialine pools are widespread, being found in areas such as Saudi Arabia, Madagascar, Fiji, and other Indo-Pacific islands, the total area occupied by them globally is extremely small. While a number of species of anchialine shrimp (e.g., *Callinectes pholidota*, *Antecaridina lauensis*) have disjunct, global distributions within these habitats, most geographic locations contain some endemic taxa. In the state of Hawaii, there are estimated to be over 650 anchialine pools, with over 90 percent of these occurring on the island of Hawaii. Unfortunately, approximately 90 percent of the pools on that island have been destroyed or otherwise impacted by development or other human uses. Pools on Oahu have been impacted by or are under current threat from development (personal communication 1998 cited in U.S. Fish and Wildlife Service candidate assessment form).

POPULATION STATUS

Historically, *Metabetaeus lohena* has been reported on the islands of Maui, Hawaii, and possibly Oahu, but currently it is absent from most surveyed pools. Due to the rarity of this species, reliable population estimates have not been possible. Many of the rare species of anchialine shrimp, including *M. lohena*, have merely been noted as present or absent from pools that have been appropriately surveyed (typically with the aid of baiting). Complete loss of shrimp species from suitable habitat is likely the best, or only, measure of species decline since population sizes are not easily determined.

The Hawaii Natural Heritage Program ranks *Metabetaeus lohena* as Critically Imperiled.

The U.S. Fish and Wildlife Service classifies *Metabetaeus lohena* as a candidate for Endangered Species Act protection with a listing priority number of 2.

LISTING CRITERIA

A. The present or threatened destruction, modification, or curtailment of its habitat or range.

Historical range: Hawaii, islands of Maui, Hawaii and Oahu.

Current range: Hawaii, islands of Maui and Hawaii.

Land ownership: Maui: 22% state, 78% private; Hawaii: 8% Federal, 15% state, 77% private; Oahu: 20% state, 80% private.

Development of the Kona coastline area on the island of Hawaii in 1985 destroyed some 130 anchialine pools (Brock et al. 1987), and up to 90 percent of the pools on that island many have been destroyed from similar activities or the introduction of alien fish on that island (personal communication 1998 cited in U.S. Fish and Wildlife Service candidate assessment form).

Development activities on the Ewa Plain on the island of Oahu have impacted anchialine pools in that area. Habitat alteration due to recreational use is known to have occurred on the island of Hawaii and Oahu and is often evident in the amount of garbage that has been dumped in these

pools. Although not necessarily a growing threat, a number of anchialine pools are commonly used as swimming holes and have been used as birthing pools (*in litt.* 1985 cited in U.S. Fish and Wildlife Service candidate assessment form).

B. *Overutilization for commercial, recreational, scientific, or educational purposes.*

Not applicable.

C. *Disease or predation.*

Predation is considered to be the greatest threat to intact anchialine pool ecosystems (Bailey-Brock and Brock 1993; personal communication 1998 cited in U.S. Fish and Wildlife Service candidate assessment form). Anchialine pools have been used to discard or hold bait-fish and/or aquarium fish. These fish either directly consume the native shrimp or, as with introduced tilapia (*Oreochromis mossambica*), out-compete the native herbivorous species of shrimp which typically serve as the prey- base for the rarer, predatory species of shrimp.

D. *The inadequacy of existing regulatory mechanisms.*

No current protection.

Current Conservation Efforts: A small number of pools lie within State natural area reserves (NARs) and national parks. At least two State NARs were established, in part, to protect this rare habitat and the unique fauna (Holthuis 1973). No conservation agreements between Federal, State, or private landowners have been drafted or initiated and, aside from placement of some pools/pool systems within State NARs, virtually no conservation activities have been conducted.

E. *Other natural or manmade factors affecting its continued existence.*

Approximately 29 percent of the known anchialine pools on the island of Hawaii occur in areas that could be destroyed by on- going volcanic activity and/or subsidence events. However, these are not considered to be imminent threats.

REFERENCES

- Bailey-Brock, J.H. and R.E. Brock. 1993. Feeding, reproduction, and sense organs of the Hawaiian anchialine shrimp *Halocaridina rubra* (Atyidae). Pacific Science 47:338-355..5
- Banner, A.H. and D.M. Banner. 1960. Contributions to the knowledge of the Alpheid shrimp of the Pacific Ocean; Part VII. On *Metabetaeus* Borradaile, with a new species from Hawaii. Pacific Science 14:299-303.
- Bishop Museum of Honolulu. Checklist of Marine Invertebrates of the Hawaiian Islands, revised 29 January 2001. (<http://www2.bishopmuseum.org/HBS/invert/search.asp>)

- Brock, R.E., J.E. Norris, D.A. Ziemann, and M.T. Lee. 1987. Characteristics of water quality in anchialine ponds of the Kona, Hawaii, coast. *Pacific Science* 41:200-208.
- Holthuis, L.B. 1973. Caridean shrimps found in land-locked saltwater pools at four Indo-west Pacific localities (Sinai Peninsula, Funafuti Atoll, Maui and Hawaii Islands), with the description of one new genus and four new species. *Zool. Verhadenlingen* 128:3-55.
- Maciolek, J.A. 1983. Distribution and biology of Indo-pacific insular hypogeal shrimps. *Bulletin of Marine Science* 33:606- 618.

PETITION TO LIST

anchialine pool shrimp (*Palaemonella burnsi*)

AS A FEDERALLY ENDANGERED SPECIES

CANDIDATE HISTORY

CNOR 1/6/89:

CNOR 11/21/91:

CNOR 11/15/94:

CNOR 10/25/99: C

CNOR 10/30/01: C

CNOR 6/13/02: C

TAXONOMY

The taxonomic status of *Palaemonella burnsi* (Palaemonidae) as a valid species is uncontroversial (e.g., Bishop Museum 2001).

NATURAL HISTORY

Carapace length of *Palaemonella burnsi* (Holthuis 1973) is reported to range from 6-9 millimeters (mm) (0.24-0.36 inches (in)). This species is transparent, greyish-green to red, the body being somewhat transparent with coloration dependent on chromatophore (pigment cells) expansion/contraction. There is often a transverse, median pale band across the carapace arranged of white chromatophores. The conspicuous, elongate chelapeds (claws) typically are greyish-green. Black pigments are associated with the well developed eyes.

Almost nothing is known about the reproductive biology or of the diet of this shrimp although collected females carried numerous, small eggs on the ventral abdomen (Holthuis 1973).

Palaemonella burnsi is known to occur from high-salinity (24-27 parts per thousand (ppt)) anchialine pools. Anchialine pools are land-locked bodies of water that occur coastally but are not openly connected to the ocean (Macioleck 1983). They are mixohaline, with salinities typically ranging from 2 ppt to concentrations just below that of sea water (32 ppt), although there are pools recorded as having salinities as high as 41 ppt (Macioleck 1983). Anchialine pools are subject to tidal fluctuations. Except for some records of endemic eels, anchialine pools in Hawaii do not support native species of fish, although some species of alien fish have been introduced and are currently recognized as problems (see below).

Although anchialine pools are widespread, being found in areas such as Saudi Arabia, Madagascar, Fiji, and other Indo-Pacific islands, the total area occupied by them globally is extremely small. While a number of species of anchialine shrimp (e.g., *Callinectes pholidota*) have disjunct, global distributions within these habitats, most geographic locations contain some endemic taxa. In the state of Hawaii, there are estimated to be over 650 anchialine pools, with an estimated 90% of these occurring on the island of Hawaii. Unfortunately, approximately 90% of the pools on that island have been destroyed or otherwise impacted by development or other human uses (personal communication 1998 cited in U.S. Fish and Wildlife Service candidate assessment form).

POPULATION STATUS

Palaemonella burnsi is only known to occur in anchialine pools on the Hawaiian islands of Maui (three sites) and Hawaii (one site). Due to their rarity within these locations, population estimates have not been attempted. It is possible that fewer than 1,000 individuals remain. Many of the rare species of anchialine shrimp have merely been noted as present or absent from pools that have been appropriately surveyed (often with the aid of baiting). Complete loss of shrimp species from suitable habitat is likely the best, or only, measure of species decline since population sizes are not easily determined.

The Hawaii Natural Heritage Program ranks *Palaemonella burnsi* as Critically Imperiled.

The U.S. Fish and Wildlife Service classifies *Palaemonella burnsi* as a candidate for Endangered Species Act protection with a listing priority number of 2.

LISTING CRITERIA

A. The present or threatened destruction, modification, or curtailment of its habitat or range.

Historical range: Hawaii, islands of Maui and Hawaii.

Current range: Hawaii, islands of Maui and Hawaii.

Land ownership: State and privately owned land.

On the island of Hawaii, up to 90 percent of the anchialine pools have been destroyed or altered by human activities (personal communication 1998 cited in U.S. Fish and Wildlife Service candidate assessment form). Introduction of alien fish or bait-fish into such pools may be a major contribution to the decline of these shrimp within their habitat (see below). Although the three known Maui pools containing *Palaemonella burnsi* occur within a protected state reserve, habitat modifications by early Hawaiians and later inhabitants have occurred in the area. Damage from use of anchialine pools for swimming and bathing has been documented in the Hawaiian Islands (in litt. 1985 cited in U.S. Fish and Wildlife Service candidate assessment

form). However, this has not been documented to be a serious problem in the Maui pools where *Palaemonella burnsi* occurs.

B. Overutilization for commercial, recreational, scientific, or educational purposes.

Not applicable.

C. Disease or predation.

Predation is considered to be the greatest threat to intact anchialine pool ecosystems (Bailey-Brock and Brock 1993; personal communication 1998 cited in U.S. Fish and Wildlife Service candidate assessment form). Anchialine pools have been used to discard or hold bait-fish and/or aquarium fish (Bailey-Brock and Brock 1993). These fish either directly consume the native shrimp or, as with introduced tilapia (*Oreochromis mossambica*), out-compete the native herbivorous species of shrimp which typically serve as the prey-base for the rarer, predatory species of shrimp.

D. The inadequacy of existing regulatory mechanisms.

The three Maui pools are located in a State natural area reserve, thus receiving some degree of protection.

Current Conservation Efforts: Three of the known pools containing *Palaemonella burnsi* lie within a state natural area reserve. The rarity of this shrimp contributed to the protection received by the Maui anchialine pools (Holthuis 1973). No conservation agreements between Federal, State, or private landowners have been drafted or initiated and, aside from placement of some pools/pool systems within reserves, virtually no conservation activities have been conducted.

E. Other natural or manmade factors affecting its continued existence.

The Maui anchialine pools occur in an area that was volcanically active as recently as 250 years ago and the anchialine pool on the island of Hawaii that contains *Palaemonella burnsi* occurs in an area that could be destroyed by on-going volcanic events. However, this is not an imminent threat at either location.

REFERENCES

- Bailey-Brock, J.H. and R.E. Brock. 1993. Feeding, reproduction, and sense organs of the Hawaiian anchialine shrimp *Halocaridina rubra* (Atyidae). *Pacific Science* 47:338-355.
- Bishop Museum of Honolulu. Checklist of Marine Invertebrates of the Hawaiian Islands, revised 29 January 2001. (<http://www2.bishopmuseum.org/HBS/invert/search.asp>)

Holthuis, L.B. 1973. Caridean shrimps found in land-locked saltwater pools at four Indo-west Pacific localities (Sinai Peninsula, Funafuti Atoll, Maui and Hawaii Islands), with the description of one new genus and four new species. *Zool. Verhadenlingen* 128:3-55.

Maciolek, J.A. 1983. Distribution and biology of Indo-pacific insular hypogeal shrimps. *Bulletin of Marine Science* 33:606- 618..6

PETITION TO LIST

anchialine pool shrimp (*Procaris hawaiiana*)

AS A FEDERALLY ENDANGERED SPECIES

CANDIDATE HISTORY

CNOR 1/6/89:

CNOR 11/21/91:

CNOR 11/15/94:

CNOR 10/25/99: C

CNOR 10/30/01: C

CNOR 6/13/02: C

TAXONOMY

The taxonomic status of *Procaris hawaiiana* (Procarididae) as a valid species is uncontroversial (e.g., Bishop Museum 2001).

The shrimp family Procarididae is represented by a small number of species globally and there are only two species in the genus *Procaris*. The second species, *P. ascensionis*, is restricted to similar habitats on Ascension Island in the south Atlantic Ocean. They are regarded as an ancient lineage of shrimp and their current range is considered to be likely relictual with respect to an early global distribution.

NATURAL HISTORY

Morphology

Procaris hawaiiana (Holthuis 1973) is reported to range from 10-30 millimeters (mm) (0.40-1.18 inches (in)) in total length. This species has a pink to light-red pigmentation, darkest along the midline, with the dorsal thorax being white to yellow. Black pigments are associated with the eyes. Conspicuous chelapeds (claws) are lacking.

Behavior

Locomotion is accomplished by swimming with the swimmerets (pareopods and uropods) and occurs just above the substrate to mid-water. Almost nothing is known about the reproductive biology or the diet of this shrimp although it has been documented to scavenge other species of

anchialine shrimp and has taken frozen brine shrimp (Maciolek in Holthuis 1973) when in captivity.

Habitat

Procaris hawaiiiana is known to occur from mid-salinity (19-25 parts per thousand (ppt)) anchialine pools. Anchialine pools are land-locked bodies of water that occur coastally but are not openly connected to the ocean (Maciolek 1983). They are mixohaline, with salinities typically ranging from 2 ppt to concentrations just below that of sea water (32 ppt), although there are pools recorded as having salinities as high as 41 ppt (Maciolek 1983). Anchialine pools are subject to tidal fluctuations. Except for some records of endemic eels, anchialine pools in Hawaii do not support native species of fish, although some species of alien fish have been introduced and are currently recognized as problems (see below).

Distribution

Although anchialine pools are widespread, reported in areas such as Saudi Arabia, Madagascar, Fiji, and other Indo-Pacific islands, the total area occupied by them globally is extremely small. While a number of species of anchialine shrimp (e.g., *Calliasmata pholidota*) have disjunct, global distributions within these habitats, most geographic locations contain some endemic taxa. In the state of Hawaii, there are estimated to be over 650 anchialine pools, with an estimated 90 percent of these occurring on the island of Hawaii. Unfortunately, approximately 90 percent of the pools on that island have been destroyed or otherwise impacted by development or other human uses (personal communication 1998 cited in U.S. Fish and Wildlife Service candidate assessment form).

POPULATION STATUS

Procaris hawaiiiana is only known to occur in anchialine pools on the Hawaiian islands of Maui (two sites) and Hawaii (one site). Due to their rarity within these locations, population estimates have never been attempted. Many of the rare species of anchialine shrimp, including *P. hawaiiiana*, have merely been noted as present or absent from pools that have been appropriately surveyed (often with the aid of baiting). Total loss of shrimp species from suitable habitat is likely the best, or only, measure of species decline since population sizes are not easily determined.

The Hawaii Natural Heritage Program ranks *Procaris hawaiiiana* as Critically Imperiled.

The U.S. Fish and Wildlife Service classifies *Procaris hawaiiiana* as a candidate for Endangered Species Act protection with a listing priority number of 2.

LISTING CRITERIA

A. The present or threatened destruction, modification, or curtailment of its habitat or range.

Historical range: Hawaii (islands of Maui and Hawaii).

Current range: Hawaii (islands of Maui and Hawaii).. Known from one site on Hawaii and two sites on Maui.

Land ownership: The three anchialine pools known to contain *Procaris hawaiiiana* occur on State land. The two Maui pools are located in a natural area reserve, thus receiving some degree of protection. The Hawaii Island pool occurs on State land managed by a different State agency and is not afforded protection.

On the island of Hawaii, up to 90% of the anchialine pools have been destroyed or altered by human activities (personal communication 1998 cited in U.S. Fish and Wildlife Service candidate assessment form). Introduction of alien fish or bait-fish into such pools may be a major contribution to the decline of these shrimp within their habitat (see below). Although the two known Maui pools containing *Procaris hawaiiiana* occur within a protected state reserve, habitat modifications by early Hawaiians and later inhabitants have occurred in the area. Dumping of refuse and the introduction of fish threaten the known population on the island of Hawaii. Damage from use of anchialine pools for swimming and bathing has been documented in the Hawaiian Islands (*in litt.* 1985 cited in U.S. Fish and Wildlife Service candidate assessment form). However, this has not been documented to be a serious problem in the Maui pools where *Procaris hawaiiiana* occurs. Such impacts to the Hawaii Island pool are possible but have not, at present, been documented.

B. *Overutilization for commercial, recreational, scientific, or educational purposes.*

Not applicable.

C. *Disease or predation.*

Predation is considered to be the greatest threat to intact anchialine pool ecosystems (Bailey-Brock and Brock 1993; personal communication 1998 cited in U.S. Fish and Wildlife Service candidate assessment form). Anchialine pools have been used to discard or hold bait-fish and/or aquarium fish (Bailey-Brock and Brock 1993). These fish either directly consume the native shrimp or, as with introduced tilapia (*Oreochromis mossambica*), out-compete the native herbivorous species of shrimp which typically serve as the prey-base for the rarer, predatory species of shrimp.

D. *The inadequacy of existing regulatory mechanisms.*

No current protection.

Current Conservation Efforts: Two of the known pools containing *Procaris hawaiiiana* lie within a state natural area reserve. The rarity of this shrimp contributed to the current protection received by the Maui anchialine pools (Holthuis 1973). No conservation agreements between Federal, State, or private landowners have been drafted or initiated and, aside from placement of some pools/pool systems within reserves, virtually no conservation activities have been conducted.

E. Other natural or manmade factors affecting its continued existence.

Although not currently active, the location on Maui where *Procaris hawaiiiana* occurs has experienced volcanic activity within the last 250 years. The known anchialine pool on the island of Hawaii that contains *Procaris hawaiiiana* occurs in an area that could be destroyed by on-going volcanic or land subsidence events. However, these are not considered to be imminent threats at either location.

REFERENCES

- Bailey-Brock, J.H. and R.E. Brock. 1993. Feeding, reproduction, and sense organs of the Hawaiian anchialine shrimp *Halocaridina rubra* (Atyidae). *Pacific Science* 47:338-355.
- Bishop Museum of Honolulu. Checklist of Marine Invertebrates of the Hawaiian Islands, revised 29 January 2001. (<http://www2.bishopmuseum.org/HBS/invert/search.asp>)
- Holthuis, L.B. 1973. Caridean shrimps found in land-locked saltwater pools at four Indo-west Pacific localities (Sinai Peninsula, Funafuti Atoll, Maui and Hawaii Islands), with the description of one new genus and four new species. *Zool. Verhadenlingen* 128:3-55.
- Maciolek, J.A. 1983. Distribution and biology of Indo-pacific insular hypogeal shrimps. *Bulletin of Marine Science* 33:606- 618.

PETITION TO LIST

anchialine pool shrimp (*Vetericaris chaceorum*)

AS A FEDERALLY ENDANGERED SPECIES

CANDIDATE HISTORY

CNOR 1/6/89:

CNOR 11/21/91:

CNOR 11/15/94:

CNOR 10/25/99: C

CNOR 10/30/01: C

CNOR 6/13/02: C

TAXONOMY

The taxonomic status of *Vetericaris chaceorum* (Procarididae) as a valid species is uncontroversial (e.g., Bishop Museum 2001). *Vetericaris* is a monotypic genus and has only been recorded from Lua o Palahemo, a single high salinity anchialine pool located in the South Point area of Hawaii Island (Kensley and Williams 1986).

NATURAL HISTORY

Total length of this shrimp is approximately 5.0 centimeters (2.0 inches), not including the primary antennae, which are approximately the same length as the shrimp's total body length. Based on limited observations, *Vetericaris chaceorum* was observed to swim in midwater, never being stationary on the substrate. The shrimp uses its primary thoracic appendages (pereiopodal exopods) as well as its abdominal appendages (pleopods) for propulsion in a forward direction. Use of tail-beats for back-ward propulsion was never observed. Large chelapeds (claws) are lacking. While gut contents included fragments of other crustaceans, no feeding has been observed and it is not known if this species is a predator, scavenger, or both. Nothing is known about the reproductive biology of *V. chaceorum*.

Anchialine pools are land-locked bodies of water that occur coastally but are not openly connected to the ocean (Maciolek 1983). They are mixohaline, with salinities ranging from two parts per thousand (ppt) to concentrations just below that of sea water (32 ppt)(Brock et al. 1987). Anchialine pools are typically subject to tidal fluctuations. Except for some records of endemic eels, anchialine pools do not support native species of fish, although some species of alien fish have been introduced and are currently recognized as problems (Bailey-Brock and

Brock 1993; personal communication 1998 cited in U.S. Fish and Wildlife Service candidate assessment form).

Although anchialine pools are widespread, being found in areas such as Saudi Arabia, Madagascar, Fiji, and other Indo-Pacific islands, the total area occupied by them globally is extremely small (Maciolek 1983). While at least one species of anchialine shrimp, *Callinectes pholidota* (present in the Lua o Palahemo anchialine pool), has a disjunct, global distribution within these habitats, most geographic locations contain some endemic taxa. In the state of Hawaii there are estimated to be over 650 anchialine pools, with over 90 percent of these occurring on the island of Hawaii. Unfortunately, approximately 90 percent of the pools on that island have been destroyed or otherwise impacted by development or other human uses (personal communication 1998 cited in U.S. Fish and Wildlife Service candidate assessment form).

POPULATION STATUS

Vetericaris chaceorum has only been reported from a single location, Lua o Palahemo, on the island of Hawaii. Unlike most anchialine pools in Hawaii, which are no more than a few meters (m) in depth, Lua o Palahemo is a lava tube which reaches a depth of nearly 40 m (131 feet(ft)) and extends for a submerged, subterranean length of nearly 300 m (984 ft). Salinities within this single pool range from 20 ppt at the surface to 30 ppt at its deepest, most seaward location. Dissolved oxygen was recorded to range from 6.0 parts per million (ppm) at the surface to 0.3 ppm at the deepest sample station (Kensley and Williams 1986).

As well as being very restricted in range, relatively few individuals were encountered by Kensley and Williams (1986). There were only five detections of *Vetericaris chaceorum* during three separate dives (SCUBA). While this shrimp likely occurs in greater abundance within the crevices and cracks of the Lua o Palahemo lava tube system, it has not been observed in other anchialine pools anywhere in Hawaii. Its highly restricted range, along with present threats and lack of protection make this species highly vulnerable to extinction.

The Hawaii Natural Heritage Program ranks *Vetericaris chaceorum* as Critically Imperiled.

The U.S. Fish and Wildlife Service classifies *Vetericaris chaceorum* as a candidate for Endangered Species Act protection with a listing priority number of 2.

LISTING CRITERIA

A. The present or threatened destruction, modification, or curtailment of its habitat or range.

Historical range: Hawaii, Lua o Palahemo on the island of Hawaii.

Current range: Hawaii, Lua o Palahemo on the island of Hawaii.

Land ownership: Lua o Palahemo occurs on State land that is administered by the State of Hawaii.

Development of coastline areas has been responsible for the destruction or degradation of anchialine pools on all of the Hawaiian Islands (Bailey-Brock and Brock 1993). Up to 90 percent of the pools on the island of Hawaii may have been destroyed from such activities or the introduction of alien fish into anchialine pools (personal communication 1998 cited in U.S. Fish and Wildlife Service candidate assessment form). The South Point area of Hawaii, or Ka Lae, has been utilized as ranch land (Kahuku Ranch) for over a century, hence, land uses have greatly altered the terrestrial habitat. Lua o Palahemo now lies within lands administered by the State of Hawaii Department of Hawaiian Homes Land (DHHL). Since European contact, human use of this anchialine pool, including dumping of refuse, has degraded this habitat (personal communication 1998 cited in U.S. Fish and Wildlife Service candidate assessment form).

B. Overutilization for commercial, recreational, scientific, or educational purposes.

Vetericaris chaceorum has been collected, on a very small scale (for identification) for scientific/educational purposes on only a few occasions. There is no record of collection for commercial or recreational purposes.

C. Disease or predation.

Predation is considered to be the greatest threat to intact anchialine pool ecosystems (Bailey-Brock and Brock 1993; personal communication 1998 cited in U.S. Fish and Wildlife Service candidate assessment form). Anchialine pools have been used to discard or hold bait-fish and/or aquarium fish. These fish either directly consume the native shrimp or, as with introduced tilapia (*Oreochromis mossambica*), out-compete the native herbivorous species of shrimp which typically serve as the prey- base for the rarer, predatory species of shrimp. Introduction of alien fish may have occurred at Lua o Palahemo.

D. The inadequacy of existing regulatory mechanisms.

No current protection.

Current Conservation Efforts: None.

E. Other natural or manmade factors affecting its continued existence.

The South Point area of Hawaii is an area that could be destroyed by on-going volcanic activity and/or land subsidence. However, these are not considered to be imminent threats.

REFERENCES

Bailey-Brock, J.H. and R.E. Brock. 1993. Feeding, reproduction, and sense organs of the Hawaiian anchialine shrimp *Halocaridina rubra* (Atyidae). Pacific Science 47:338-355.

- Bishop Museum of Honolulu. Checklist of Marine Invertebrates of the Hawaiian Islands, revised 29 January 2001. (<http://www2.bishopmuseum.org/HBS/invert/search.asp>)
- Brock, R.E., J.E. Norris, D.A. Ziemann, and M.T. Lee. 1987. Characteristics of water quality in anchialine ponds of the Kona, Hawaii, coast. *Pacific Science* 41:200-208.
- Kensley, B. and D. Williams. 1986. New shrimps (families Procarididae and Atyidae) from a submerged lava tube on Hawaii. *J. Crustacean Biol.* 6: 417-437.
- Maciolek, J.A. 1983. Distribution and biology of Indo-pacific insular hypogeal shrimps. *Bulletin of Marine Science* 33:606- 618.

PETITION TO LIST

troglobitic groundwater shrimp (*Typhlatya monae*)

AS A FEDERALLY ENDANGERED SPECIES

CANDIDATE HISTORY

CNOR 5/22/84:

CNOR 1/6/89:

CNOR 11/21/91:

CNOR 11/15/94:

CNOR 10/25/99: C

CNOR 10/30/01: C

CNOR 6/13/02: C

TAXONOMY

Typhlatya (Atyidae) is an almost exclusively subterranean genus of small shrimps represented worldwide by eleven species.

NATURAL HISTORY

These ground-water shrimp are classified as troglobites or obligatory cave organisms; their most striking feature is the reduction or loss of vision and pigmentation. *Typhlatya monae* is small, reaching 4.5 millimeters (0.2 inches) in carapace length, with a translucent body and with a pigmented spot in the eyestalk. Some individuals may appear to be light yellow-orange due to the color of the internal organs.

This shrimp feeds on organic waste material and debris, and a steady input of fresh organic material that is available in the caves. It is believed that the shrimp is not restricted to a cave's aquatic habitat, but may also be found within the aquifer conduit system connecting the cave's groundwater environment.

Both the Guánica Commonwealth Forest and Mona Island are managed by the Puerto Rico Department of Natural and Environmental Resources. Both are located within the subtropical dry forest life zone, in areas that overlie a limestone substrate. In these areas the vegetation is typically more xerophytic than that of other soil types in this life zone. Mean annual precipitation in the life zone is approximately 66 centimeters (25.7 inches), distributed in distinct wet (August through November) and dry (January through March) seasons. Mean annual

temperature in Guánica has been reported to be 25.3°C, with a mean monthly minimum of 23.5°C and a mean monthly maximum of 26.7°C.

The Guánica Commonwealth Forest is located in the municipalities of Guánica, Yauco, and Guayanilla in southwestern Puerto Rico and encompasses an area of about 4,000 hectares (9,880 acres). Twelve known caves are found in the forest, most of them formed within the Ponce limestone by solutional processes at the fresh-saltwater mixing zone. A total of 34 invertebrate species has been reported from these caves and, of the five aquatic troglobitic species known from Puerto Rico, three are found in the ground waters of Guánica.

Mona Island is located approximately 68 kilometers (42 miles) to the west of Puerto Rico and is about 5,500 hectares (13,585 acres) in size. Mona is a flat limestone plateau bounded by high vertical cliffs. Twenty-five major caves, distributed along the periphery of the island, have been documented. The majority have been formed at the contact between Lirio limestone and the underlying Mona Dolomite by solutional processes. The entrances are usually found on sea cliffs where openings have formed from roof collapse. Most of the caves are dry, but two provide access to the aquifer's water table. Forty-six invertebrate species have been documented in these caves, of which three are troglobitic.

The distribution of the 11 known *Typhlatya* species is disjunct and includes Mexico, the Antillean islands, Bermuda, Ascension Island, and the Galapagos (Hobbs 1994). Four species occur in the Antilles, including *Typhlatya monae*. *Typhlatya monae* was discovered in 1954 from Mona Island, an island located to the west of Puerto Rico. The specimens were collected from water located in a concrete basin at the Mona airstrip. The basin contained groundwater that had been pumped into it from an adjacent well. It was later (1974) found in two caves in the Guánica Commonwealth Forest, located in the southwestern part of Puerto Rico (Peck 1981). This groundwater shrimp species has also been found in Barbuda (Chace and Hobbs 1969) and in the Dominican Republic (Hobbs et al. 1977). Little is known concerning this species' status in either Barbuda or the Dominican Republic.

POPULATION STATUS

In the three caves where it is known to be extant populations are estimated at 1,970, 40, and 2 individuals (U.S. Fish and Wildlife Service 1999).

Surveys conducted in 1974 (Peck and Kukulova-Peck 1974) and in 1995 (Conde-Costas and Gonzalez de Segal 1996) on Mona Island did not locate any specimens of the shrimp at the historical locality or at other areas surveyed on the island. Currently, in Puerto Rico, the species is known only from three caves in the Guánica Commonwealth Forest: El Refugio, Carmen, and Los Murcielagos. The largest population was found in the lagoon located in the El Refugio cave. Individuals were distributed in a clumped or patchy pattern, caused perhaps by a patchy distribution of food. Estimates of 1,970 individuals in the El Refugio cave, 40 in the Carmen cave, and two in the Los Murcielagos cave were made in 1995. *Typhlatya monae* was found in varying light conditions and in moderately saline, alkaline water low in oxygen. Bat guano was the primary source of organic material (Conde-Costas and Gonzalez de Segal 1996).

The U.S. Fish and Wildlife Service classifies *Typhlatya monae* as a candidate for Endangered Species Act protection with a listing priority number of 5.

LISTING CRITERIA

A. The present or threatened destruction, modification, or curtailment of its habitat or range.

Historical range: Puerto Rico, Barbuda, Dominican Republic.

Current range: Puerto Rico, Barbuda, Dominican Republic. Three caves in the Guánica Commonwealth Forest: El Refugio, Carmen, and Los Murcielagos.

Land ownership: All known sites in Puerto Rico are located on land owned and managed by the Commonwealth of Puerto Rico.

The largest population in Guánica is found in the El Refugio cave. This is also the most accessible of the caves and is, therefore, the most vulnerable to human impact. Human impact may result from contamination of the lagoon, as well as from vandalism, including fires, and collection. These caves are visited frequently and a large amount of trash accumulates in them. An additional threat to the species may be from the development of the groundwater resources, resulting in a change in groundwater quality, as well as pumping, and the resultant removal of individuals. Contamination of recharge areas from landfills or spills from storage tanks may result in the contamination of groundwater in the Guánica caves.

While the species was not found on the island of Mona in 1995, Conde-Costas and Gonzalez de Segal (1996) indicated that the species may still be found in the reef deposits aquifer on the island's southwest coastal plain. Development of this groundwater resource may result in water quality changes or actual removal of the individuals. Although the island is designated as a Natural Reserve, managed by the Department of Natural and Environmental Resources, numerous developments, including a superport, a prison, and most recently, a hotel, have been proposed. Such facilities would require a source of freshwater.

B. Overutilization for commercial, recreational, scientific, or educational purposes.

While collection has not been documented to be threat, it may become a threat in the future because the Guánica caves are open to the public and receive frequent visitation.

C. Disease or predation.

Neither disease nor predation has been documented as a threat to the species. Nevertheless, predation by species such as the introduced marine toad (*Bufo marinus*) may become a threat in the future.

D. *The inadequacy of existing regulatory mechanisms.*

The species is not currently protected by the Commonwealth of Puerto Rico. Federal listing would result in its inclusion as an endangered species under the Commonwealth's Regulation for the Management of Vulnerable and Endangered Species. Although Mona Island and the Guánica Forest are managed by the Commonwealth, development projects continue to be proposed in both areas.

Current Conservation Efforts: None.

E. *Other natural or manmade factors affecting its continued existence.*

Typhlatya monae is currently known only from one large population and two additional localities where very few individuals have been found. Little is known concerning its status in either Barbuda or the Dominican Republic, but Caribbean islands in general are under intense development pressure. One of the most important factors affecting the continued survival of the species is its limited distribution. Any catastrophic event or impact from humans (e.g., contamination) that affects the major population may result in the extinction of the species.

REFERENCES

- Chace, F. A. and H. H. Hobbs. 1969. The freshwater and terrestrial decapod crustaceans of the West Indies. U.S. National Museum Bulletin 292. 258 pp.
- Conde-Costas, C. and C. Gonzalez de Segal. 1996. Distribution, abundance and habitat characterization of the troglobitic groundwater shrimp - *Typhlatya monae* in Puerto Rico. Tierra Linda Consultants. 69 pp.
- Hobbs, H. H., H. H. Hobbs III, and M. A. Daniel. 1977. A review of the troglobitic decapod crustaceans of the Americas. Smithsonian Contributions to Zoology 244: 39-43.
- Hobbs III, H. H. 1994. Biogeography of subterranean decapods in North and Central American and the Caribbean region. Hydrobiologia 287: 95-104.
- Peck, S. B. 1981. Zoogeography of invertebrate cave faunas in southwestern Puerto Rico. National Speleological Society Bulletin 43: 70-79.
- Peck, S. B. and J. Kukalova-Peck. 1974. The subterranean fauna and conservation of Mona Island: A Caribbean karst environment. National Speleological Society Bulletin 43: 59-68.
- U.S. Fish and Wildlife Service (USFWS). 1999. Candidate and listing priority assignment forms.