

ENDANGERED SPECIES RELOCATION ASSESSMENT
CIVILIAN-MILITARY COMPLEX PORT DEVELOPMENT
JEJU ISLAND, SOUTH KOREA

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September 2012

TABLE OF CONTENTS

1.0 EXECUTIVE SUMMARY	1
2.0 STATUS AND NATURAL HISTORY OF TARGET SPECIES.....	1
3.0 METHODS	6
3.1 HABITAT ASSESSMENT SURVEYS OF RELOCATION SITES.....	6
3.2 HABITAT REQUIREMENTS FOR <i>K. BOREALIS</i>	7
4.0 RESULTS	7
4.1 TARGET SPECIES OCCURRENCES IN THE PROJECT VICINITY.....	7
4.2 HABITAT ASSESSMENT.....	7
4.4 RELOCATION CONCERNS AND FAILURES.....	13
4.5 LACK OF TRANSPARENCY AND MONITORING ISSUES.....	15
5.0 CONCLUSIONS AND RECOMMENDATIONS.....	16
6.0 LITERATURE CONSULTED	18

Appendix:

Appendix A: Photographs

1.0 Executive Summary

During 2010 and 2011, *Sesarma intermedium* (estuary crab), *Caridina denticulata keunbaei* (Jeju freshwater shrimp), and *Kaloula borealis* (boreal digging frog) were all relocated to three different sites from the navy base construction site in Gang jeong-dong Village, Seoqwipo City, Jeju Island, South Korea. Further investigations were carried out independently by Endangered Species International (ESI) during August 2012 to assess the habitat and relocation of these three endangered species.

Findings from the habitat and species relocation assessments show failed relocation for the endangered *K. borealis* where all breeding frogs were left on site and only tadpoles were removed. The released tadpoles are thought to have a low survival rate due to the presence of potential predators. Monitoring for *K. borealis* should have been conducted just after the release event in August 2011 but only started in part during 2012. Early observations of larval growth and development stages to metamorphosis were therefore not recorded. Finally, the lack of transparency from the government and those conducting monitoring activities preclude the need for adequate independent monitoring of the boreal frog relocation.

The relocation of the *C. denticulata keunbaei* was incomplete, as a population still remained on site. Further, 5,300 shrimps were released downstream along Gangjeong Creek where a population of *C. denticulata keunbaeis* had already been established. This increased the risk of surpassing the carrying capacity of this area. Shrimps should have been released at other alternative suitable sites to increase the chance of their survival. Since no further monitoring is possible for shrimps, the success of their relocation will remain unknown.

The endangered *S. intermedium* was released along Gangjeong Creek, but this area was later impacted by human activities. Suitable habitat protection was therefore not provided as stated in the relocation report as all relocation sites should have been protected to allow for successful survival and establishment of the species.

Immediate measures are urgently needed to insure survival of the three relocated species. Since a population of endangered *K. borealis* and *C. denticulata keunbaei* remain on site it is essential to stop construction activities until the frogs and shrimps are removed using appropriate survey method. The population should then continue to be independently monitored. Further important measures and recommendations are included in this report.

2.0 Status and Natural History of Target Species

The three species which were relocated from the proposed Jeju Naval Base, Gangjeong Village in Seogwipo are *Sesarma intermedium* (*S. intermedium*), *Caridina denticulata keunbaei* (*C. denticulata keunbaei*) and *K. borealis* (*K. borealis*). *S. intermedium* and *K. borealis* are both classified under Class II Endangered Wildlife by the Ordinance of the Ministry of the Environment of South Korea. Class II Endangered Wildlife are species facing natural or

anthropogenic factors threatening their populations and if mitigation is not in place in the near future, risk of extinction in the wild is likely.

From June 2010 - October 2011, 322 *S. intermediums* were relocated to Seongwenna Creek, Yakcheonsa, Daepo-dong, Seoqwipo City. About 5,300 *Caridina denticulata keunbaei* were relocated to Gangjeong Creek, Gang jeong-dong Village, Seoqwipo City from October to December 2010. From June – September 2011, 918 *K. borealis* tadpoles *K. borealis* were relocated in 3 manmade ponds in Jeju Stone Park in Jeju City.

Sesarma intermedium (S. intermedium)

Conservation Status

- Endangered and Protected Species, Level II designated by Korean Ministry of Environment in 2004.
- Not yet classified on the IUCN Red List.

Range

Mergui Archipelago

Japan: Tokyo, Amami-Oshima and Shimoda, Shimoda, Shimoda and Nagasaki, Hachijo-jima, Sagami Bay, Hakata Bay, from Tokyo Bay to Nagasaki and Yaeyama-retto, Tobishima, Yamagata Prefecture, Midori-gawa, Kumamoto

Korea: Euisan Ri, Daecheon, Sinchang, Jeju Island and Gaeso Ri

China: Hong Kong, Shanghai, Ningbo, and Fuzho

Indonesia: Surabaya, Java

Range on Jeju Island

Information incomplete, but known to include Gureombi Rock. 332 individuals relocated to Yakcheonsa, Daepo-dong and Seoqwipo City.

Habitat and Ecology

Sesarma intermedium is a largely terrestrial species, inhabiting reed fields, rice paddies, swamps and marshes along estuarine shores, building burrows and spending the majority their lifespan on land,. Larvae are known to expire quickly in freshwater and total lifespan is estimated at less than 3 years. *Sesarma intermedium* display sex specific feeding habits, with females proving to be more specialized, preferring leaves over algae, when available. Males of the species consume a diet of both algae and leaves.

Previous Habitat at the Jeju Civilian-Military Complex Port Project

Sesarma intermedium was known to occupy freshwater pools and wetland areas near seashore.

Description

Carapace perfectly quadrangular, the lateral borders feebly divergent backwards, armed with two teeth including the external orbital angle, the vestige of the third tooth can be traced out in some specimens. The front medially marked with broad sinus and the postfrontal ridge well marked, four-lobed. The outer surface of palm is covered with depressed tubercles mainly near the middle surface; a patch of larger granules occurs a little below the middle portion of this surface; on the

inner surface; a ridge of large tubercles extends from the middle of the superior border toward the middle portion, the remainder of the surface also covered with fine granules. The fingers are not much gaping even in full grown male.

Sexual dimorphism – males chelipeds hypertrophied (function thought to be for digging larger burrows and for mating, no obvious feeding advantage).

Breeding

After a six month hibernation period, *Sesarma intermedium* mates from May – July. Daily activity is bimodal, with two peaks; one before sunrise and one just after sunset. By August, most females are carrying eggs and thus almost no further mating occurs. Copulation occurs both in the burrow and on the surface of available natural shelter. Females can be seen to be gravid from May/June (depending on distance from the sea,) onwards and are able to oviposit three times without repeated mating necessary. On average, egg incubation lasts for thirty days with larval release appearing to be strongly influenced by both the time of day and month, peaking at sunrise and sunset and during new and full moon periods. The larvae are released just after high water of spring tides and around high water on the days following the full and new moons. This semilunar rhythm gives the larvae a greater chance of reaching the sea. Gravid females have been observed to release their clutches as far as 1.5km from the sea.

Threats

Habitat loss and fragmentation are the leading factors in a continuous decline of their populations.

Jeju's *Caridina denticulata keunbaei* / *Neocardina denticulate* (*C. denticulata keunbaei*)

Conservation Status

- Endangered and candidate protected species by Korean Ministry of Environment under the Wildlife Conservation and Management Act.
- Not yet classified on the IUCN Red List.

Range

A subspecies that is only found on Jeju Island.

Habitat and Ecology

This species inhabits inland bodies of fresh water, including streams, ponds, swamps and rivers. Preferred conditions of the closely related *Neocaridina denticulata sinensis* are broad, from soft and slightly acidic (pH 6.0–7.0) to very alkaline (pH 7.0–8.4). Average population density 34–180 individuals per m². Dispersed during rainy season.

Breeding

Breeding is more likely and successful in warmer water. Close relatives of the species are said to be extremely prolific, with a healthy colony will quickly multiplying. Females will be constantly pregnant. It is typically 30–45 days from pregnancy to hatching. The female carries over 25 eggs at adulthood. Breed usually June–July. Multiple ovulations during breeding season. Each egg

batch weighs ~44% of female body weight and gonads significantly enlarged suggesting high investment in breeding. Abbreviated larval development and large egg size (evidence for landlocked species).

Threats

Habitat alteration and loss, drainage of habitat, local pesticides, fertilizers, and other pollutants.

***Kaloula borealis* (*K. borealis*)**

Conservation Status

- Endangered Species, Level II designated by Korean Ministry of Environment under the Wildlife Conservation and Management Act.
- IUCN list this species under 'Least Concern' in view of its wide distribution, tolerance of a broad range of habitats, presumed large population, and because it is unlikely to be declining fast enough to qualify for listing in a more threatened category. Rapid decline in South Korea.

Range

K. borealis is found in China, the Democratic People's Republic of Korea, and the Republic of Korea, including Jeju Island. In Korea, *K. borealis* is classified as endangered.

Previous surveys for *K. borealis* in Jeju Island (Sang Beom Ko et al., 2011) revealed that 83 aquatic areas were often used as breeding sites. Breeding habitat was generally shallow and did not exceed 50 cm deep. The northern half of Jeju Island has 54 breeding sites and the southern half has 24 sites. *K. borealis* is known to occur in recently designated Wetland Conservation Area (2011) - Dongbaekdongsan (59 ha; 33°31'N 126°43'E) in Jeju-do Province which is an important site for conservation of the species. *K. borealis* is still widespread in Jeju: however with the rapid loss of breeding habitats, population decline is severe.

Description

The body is stocky (~4.5cm adult body length), with a small head and short, rounded snout. The dorsal skin is covered by irregularly scattered spots, and the ventral part is grey/white with scattered yellow speckles. There is no difference in size between males and females; however; males have folded vocal sacs and distinct black speckles in the throat area. Males do not have nuptial pads during breeding season.

Habitat

Terrestrial (primarily) and fresh water - paddy fields and other cultivated/irrigated land, rural gardens and artificial ponds, temperate forest, inland wetlands (permanent and seasonal freshwater marshes/pools under 8ha).

Breeding

K. borealis breeds in ponds, ditches and stagnant rainwater pools during rainy season (June-August). Develops from egg to adult in 20-40 days (high metabolism and very fast development of gills and lungs). Clutches of 15-20 eggs, which hatch within 28-30 hours. Males lure females by sound during the night. In Jeju Island, *K. borealis* uses permanent wetland (51.8%), stream

parts where water is stagnant (22.9%), temporary wetland during rainy season (19.3%), and waterway near farmland (6%) (Sang Beom Ko et al., 2011).

Behavior

Hides in burrows, between rocks and is nocturnal. Hibernates in winter until mid-May (~6 months).

Threats

Habitat alteration and loss, urbanization, drainage of habitat, pesticides, fertilizers, and pollutants.

The island nature of the species' means that it has become genetically separated from the majority of other populations, resulting in low genetic variability ($H_e=0.045$), gene flow ($N_m=0.487$) and a high inbreeding coefficient. Evidence of the chytrid fungus has been documented in populations of the introduced bullfrog in South Korea.

Table 1. Habitat, activity and threat summary of target species

Species	Habitat Characteristics	Breeding Habitat	Activity	Threats
<i>Sesarma intermedium</i>	Terrestrial species inhabiting reed fields, rice paddies, swamps and marshes along estuarine shores. Spends the majority of its time in its burrow.	Copulation occurs both in the burrow and on the surface of available natural shelter.	Hibernate for 6 months of the year. Breeding season runs from May - July. Daily activity is bimodal, with two peaks; one before sunrise and one just after sunset. On average, egg incubation lasts for thirty days with larval release appearing to be strongly influenced by both the time of day and month, peaking at sunrise and sunset and during new and full moon periods.	Habitat alteration and loss. Urbanization. Drainage of habitat. Local pesticides, fertilizers, and pollutants. Potential inbreeding due to reduced numbers and thus loss of genetic diversity
<i>Caridina denticulata keunbaei</i>	Inland bodies of fresh water, including streams, springs and lakes.	Breeding is more likely and successful in warmer water.	Diurnal and nocturnal.	General habitat alteration and loss Drainage of habitat Local pesticides, fertilizers, and pollutants.
<i>K. borealis</i>	Inhabits cultivated fields, rice paddies and ponds. Except during the breeding season this frog lives predominantly on land, hiding in underground burrows or in sheltered areas during the day.	Breed in ponds, ditches and rainwater pools. Breeding occurs during the rainy season (June and July in Jeju island), taking advantage of monsoonal pools.	Largely nocturnal, hiding underground or in protected places during the day.	General habitat alteration and loss.

3.0 Methods

Prior to conducting field surveys and assessment, Endangered Species International (ESI) reviewed pertinent information on *S. intermedium*, *C. denticulata keunbaei*, and *K. borealis*. Sources reviewed for the capture and relocation of target species included the following reports:

- Korea Engineering Consultants Corp. 2012. Endangered wildlife (*Sesarma intermedium*) capture and relocation report (an official document for the Yongsan River Basin Environmental Office).
- Yongsan River Basin Environmental Office. 2012. Endangered wildlife (*Sesarma intermedium*) capture and relocation notification permit for Ecocean.
- Ecocean. 2011. Jeju Naval Base construction project. Endangered (*Sesarma intermedium*) trapping, relocation, and monitoring plan.
- Korea Engineering Consultants Corp. 2012. Endangered wildlife (*K. borealis*) capture and relocation report (an official document for the Yongsan River Basin Environmental Office).
- Yongsan River Basin Environmental Office. 2012. Endangered wildlife (narrow-mouthed toad) capture and relocation notification permit (an official document for Environmental Planning Institute).
- Environmental Planning Institute, Jeju. 2011. Jeju Naval Base narrow-mouthed toad trapping, relocation and monitoring plan.

Satellite photographs were reviewed to identify habitats including ponds and streams, including pictures taken prior to the start of the naval base construction.

3.1 Habitat Assessment Surveys of Relocation Sites

Field surveys were carried out to document the aquatic and surrounding upland habitat conditions and to evaluate the ability of relocation habitat to support target species. Habitat assessments were conducted from August 4-10, 2012. Field surveys of the target species were conducted day and night at Seongwennae Creek, Gangjeong Creek and the three man-made ponds in Jeju Stone Park. Snorkeling was conducted along Gangjeong creek from the dam to downstream searching for additional presence of *C. denticulata keunbaei* in large pools.

At each site assessed, data was collected on aquatic habitat type and habitat features relevant to the three target species. This was done by visually observing, estimating, and recording width and depth of water bodies, type of substrate, percent of floating and emergent vegetation, percent of shade, bank and shoreline slope, number of pools, and woody debris. Photos were taken at water features to characterize the habitat; representative photographs of the sites assessed are included in Appendix A. Upland habitats were evaluated to a distance of 150 m out from the edge of released aquatic sites. Upland habitat features such as downed trees, logs, small burrows and moist leaf litter were noted.

To reduce the spread of disease agents and parasites between sites that affect amphibians, ESI biologists followed the Code of Practice, as prepared by the Declining Amphibian Populations Task Force (DAPTF 1998). After surveying each site, field equipment and footwear were rinsed with sterilized water (i.e., boiled or treated), scrubbed and rinsed.

3.2 Habitat requirements for *K. borealis*

Suitable aquatic breeding habitat

Suitable aquatic breeding habitat provides space, food, and cover necessary to sustain all life stages. For *K. borealis*, the ephemeral aquatic habitat must retain water for a minimum of three weeks to allow metamorphosis and provide a good muddy substrate to allow fast burrowing.

Suitable aquatic non-breeding habitat

Suitable aquatic non-breeding habitat consists of aquatic habitat that does not retain water long enough for *K. borealis* to complete its life cycle. However, aquatic non-breeding habitat provides shelter, foraging, and aquatic dispersal for juvenile and adult frogs.

Suitable aquatic habitat

Suitable aquatic habitat includes suitable aquatic breeding and non-breeding habitat described above.

Upland habitat

Upland habitat includes grasslands, woodlands and/or wetland/riparian vegetation communities that provide foraging and shelter from predators for *K. borealis*. Upland habitat can also include structural features such as organic debris (e.g. downed trees, logs), small burrows and dense leaf litter. Microhabitats such as burrows and dense vegetation that provide shelter are essential feature for the survival of *K. borealis*.

4.0 Results

4.1 Target Species Occurrences in the Project Vicinity

Consultation with locals revealed that no known record exists of *K. borealis* within 10 km of the project area. However, *C. denticulata keunbaei* is known to occur in Gangjeong Stream just 50 m away from the construction site. *S. intermedium* is known to occur just 30 m from the construction site where freshwater pools with vegetation and rocks persist. The project area is within the Jeju Island historic and current range of the three target species and suitable habitat sites exists inside and outside the construction project site.

4.2 Habitat Assessment

Habitat assessments were conducted at three main sites where target species were relocated from the construction site during 2011. Assessment occurred at Seongwenna Stream for *Sesarma intermedium* (*S. intermedium*), Gangjeong Stream for *Caridina denticulata keunbaei* (*C.*

denticulata keunbaei), and three ponds located within Stone Museum for *K. borealis* (*K. borealis*).

Seongwennae Stream (relocation site for *S. intermedium*)

Seongwennae Stream was assessed from downstream at the ocean to upstream until 90 m above the road bridge for a total length of 470 m (Figure 1). Release sites located about 100 meters upstream from the mouth of the stream were searched as potential micro-habitat for target species.

Seongwennae Stream is a 4-8 m wide creek with a substrate composed of silt, gravel, cobbles boulders and bedrock. The creek has dense riparian vegetation along some of the banks, permanent pools up to 1.5 m deep and some refuge sites near the banks (e.g., dense vegetation and boulders) that provide suitable habitat for *S. intermedium*. Backwater pools up to 0.5 m are present along the banks and provide potential aquatic habitat for *S. intermedium*. Overall, the site has a medium habitat quality due to potential future negative impacts caused by the existing trail along the creek and vegetation clearing activities along the bank. Seongwennae Stream is not a protected habitat and future habitat viability of the site is questionable, especially at the release site. Since no surveys (existing population assessment and density) for *S. intermedium* were conducted prior to release events, competition for food and space with other crab species and/or the same species is unknown, leaving vast uncertainty for their survival and establishment in the released site. The creek upland habitat is also surrounded by crop plantation, furthering the potential negative impacts in the area due to run-off from fertilizers used on the crops.

At the release site, backwater pools were present along the stream. Boulders and large cobbles were also present near the bank providing refuge for crabs during inactivity period. The right bank (looking downstream) within the upland habitat at the release site was significantly impacted by clearing of vegetation, rendering the habitat with low sustainability for crabs (Figure 2).

Figure 1. Location of Seongwennae Stream (downstream) where habitat assessment was conducted.

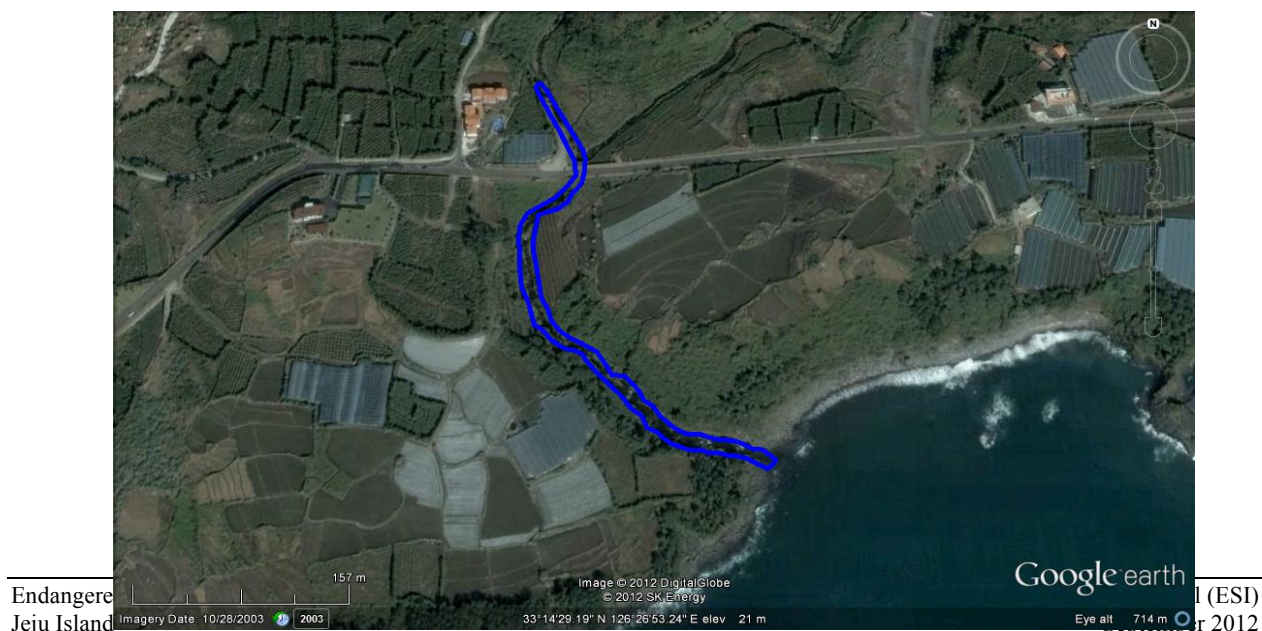


Figure 2. Release site and impacted area (in red) along Seongwenna Stream.

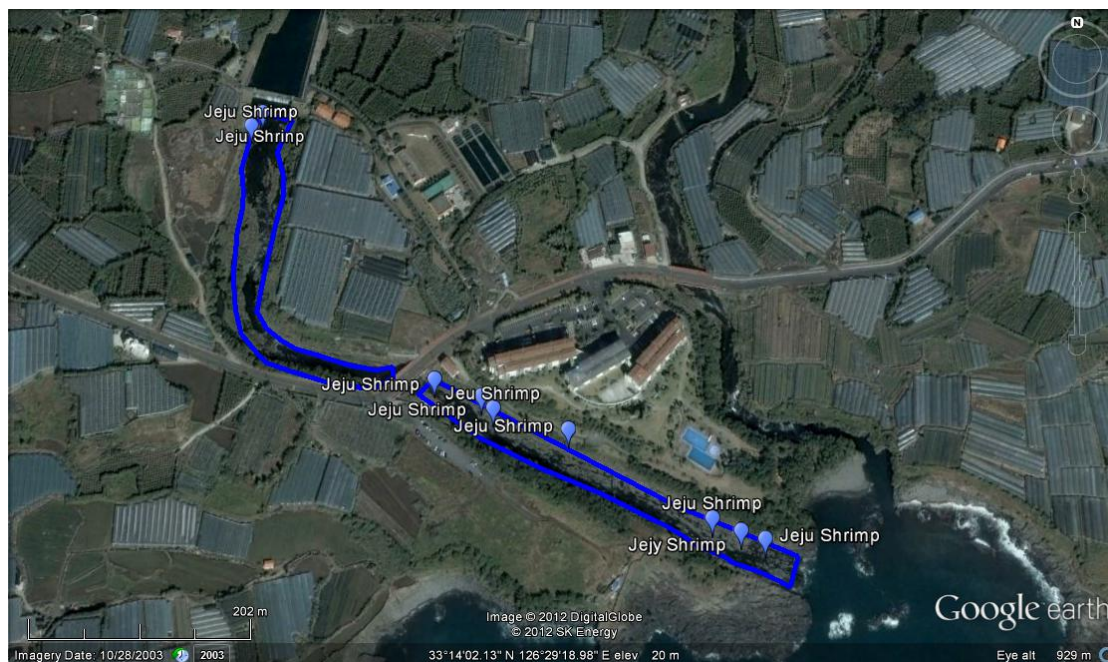


Gangjeong Creek (relocation site for *C. denticulata keunbaei*)

Gangjeong Creek was assessed from its mouth up to 800 m upstream where the reservoir is located (Figure 3). The substrate of the creek is mostly composed of bedrocks, boulders and cobbles. Gangjeong Creek provides a good quality habitat for *C. denticulata keunbaei*. Many backwater pools are fed by underground/spring water, with some emergent vegetation along the bank providing suitable habitat for the *C. denticulata keunbaeis*. In general, pools are shallow, have no turbidity and lack predatory fishes.

C. denticulata keunbaeis were observed prior to the relocation but population estimates and density studies along Gangjeong Creek were not conducted. During our habitat assessment (post relocation), many pools were occupied by *C. denticulata keunbaei*, with one pool containing up to 30 shrimps. *C. denticulata keunbaeis* appeared common along the surveyed site and were also widespread upstream where no shrimps were released (Figure 3). Since it is impossible to differentiate between released and non-released shrimps along the creek, the success of the relocation cannot be ascertained.

Figure 3. Location of Gangjeong Creek (downstream) where habitat assessment conducted and *C. denticulata keunbaeis* were observed.



Stone Museum Ponds (relocation site for *K. borealis*)

The Stone Park Museum supports three artificial ponds build in 1999 (Figure 4; Ponds 1-3) where *K. borealis* tadpoles were released in July and August 2011. A total of 918 tadpoles were released and no adults were captured or relocated. The number of tadpoles released per pond is not available and not mentioned into the relocation report (Korea Engineering Consultants Corp. 2012). The closest known occurrence of *K. borealis* is located 3-4 km from Stone Museum (Dr. Oh Hong Sik, personal communication to Green Korea, September 2012).

Pond no.1 has a perimeter of 77.5 meters, an area of 430 m², and a maximum depth of about 60 cm. Substrate of the pond was low with low capability for burrowing. Emergent vegetation was important and covered 60-70% of the pond. Pond no. 2 has perimeter of 82 meters, an area of 493 m² and maximum depth of about 50 cm. Substrate is similar to pond 2 with about 40-50 of emergent vegetation. Pond no. 3 has perimeter of 49 meters, an area of 175 m² and maximum depth of 10 cm. Substrate was very muddy allowing fast borrowing essential to *K. borealis*. Emergent vegetation is almost absent. Pond no.3 may become seasonal, whereas ponds no.1 and 2 are permanent.

The habitat quality of ponds 1 and 2 is considered moderate for *K. borealis* due to low substrate quality for burrowing. The habitat quality of pond 3 is good by providing a good substrate for *K. borealis*. The shorelines are characterized by very low slopes. Shade from canopy is usually absent for all ponds. Upland habitat is characterized by open grassland areas and patched forest.

Figure 4. Location of Stone Museum Ponds.

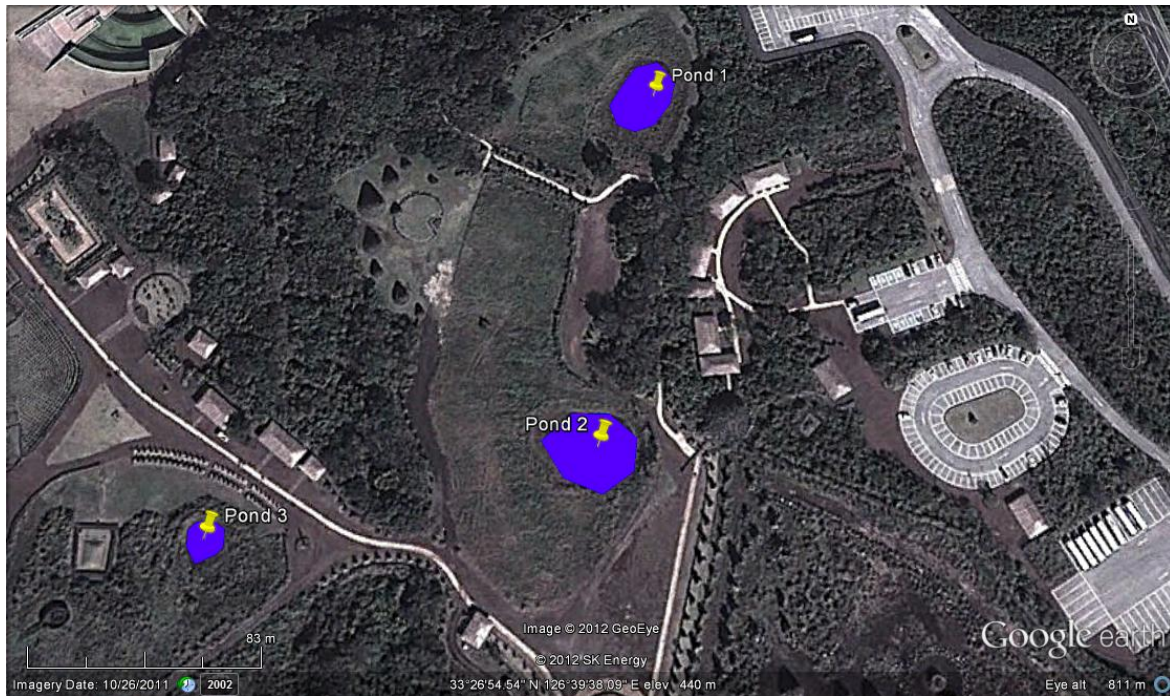


Table 2. Habitat characteristics of relocation sites.

Feature / Habitat type	Water bodies: (permanent or seasonal)	Length/Width or Area/Max. Depth (meters)	Bank gradient/ Water flow	Dominant Substrate	% floating vegetation % emergent vegetation % shade	Suitable breeding habitat for target species?	Suitable dispersal and foraging aquatic habitat?	Constraints for species relocation
<i>Kaloula borealis</i>								
Stone Museum Pond 1	Permanent	430 m ² 0.6	Low/ none	Silt-clay	20 10 20	Medium	Yes	Low burrowing capability and high density of dark-spotted frog.
Stone Museum Pond 2	Permanent	493 m ² 0.5	Low/ none	Silt-clay	0 0 10	Medium	Yes	Low burrowing capability

Feature / Habitat type	Water bodies: (permanent or seasonal)	Length/ Width or Area/ Max. Depth (meters)	Bank gradient/ Water flow	Dominant Substrate	% floating vegetation % emergent vegetation % shade	Suitable breeding habitat for target species?	Suitable dispersal and foraging aquatic habitat?	Constraints for species relocation
<i>Kaloula borealis</i>								
Stone Museum Pond 3	Appears to be seasonal	175 m ² 0.1	Low/ none	Silt-clay	0 0 0	high	Yes	Small size pond can only contain small population density of <i>K. borealis</i>
<i>Caridina denticulata keunbaei</i>								
Gangjeong Creek	Permanent with backwater pools	800 m (length assessed) 15-25 m 1.8 m	Medium to high/ medium	Bedrocks, boulders and cobbles	0 20 10	High	Medium	<i>C. denticulata keunbaei</i> already present at the relocation site; high risk of over population and predation.
<i>Sesarma intermedium</i>								
Seongwennae Creek	Permanent with backwater pools.	470 m (length assessed) 4-8 m 1.5m	Medium to high/	Bedrock, boulders, cobbles, gravels	0 10 10	Medium (estuary access)	Medium	Human impacts along bank and trail access. High density of other crab species.

Gradient: Low < 4 %, Medium 4-35%, High >35%

During habitat assessment, the dark-spotted frog *Pelophylax nigromaculatus* or also named *Rana nigromaculata* was observed at ponds no.1 and 2. The lack of emergent vegetation at pond no.3 reduced the habitat viability for *P. nigromaculatus*. The Japanese tree frog *Hyla japonica* and the Dybovsky's frog *Rana dybowskii* are also known to occur at Stone museum (review of data and rational for selecting Jeju Stone Museum for the relocation site for *K. borealis*). Even though *K. borealis* is known to co-exist with the three other anuran species, tadpoles and metamorphs could be prey of both *Pelophylax nigromaculatus* and *Rana nigromaculata*. Therefore, tadpoles should have been released at ponds where the number of *Pelophylax nigromaculatus* and *Rana nigromaculata* was the least, suggesting that ponds no.3 and no.2 are likely better sites.

4.4 Relocation concerns and failures

4.4.1 *Sesarma intermedium*

S. intermedium was relocated to the Seongwennaek Creek, but there could be significant negative impacts on the crabs' potential survival and establishment. A trail exists and future increase in visits could affect vegetation along the banks. Further, the site should be granted protection; however a significant portion of the bank has already been cleared by a private owner, both near the release site and then further after the release.

4.4.2 *Caridina denticulata keunbaei*

C. denticulata keunbaei were relocated to the Gangjeong Creek where monitoring of relocation is not possible. The *C. denticulata keunbaeis* were already present at the creek and the individuals released were not marked. Success or failure of relocation is therefore unknown. Since *C. denticulata keunbaei* were already present in Gangjeong Creek, the release of 5,300 individuals in a limited habitat could surpass the carrying capacity for the area. A number of shrimps should have been released at other suitable site(s) to avoid potential intraspecific competition. The carrying capacity of the *C. denticulata keunbaei* in Gangjeong Creek was probably at the maximum that the stream can sustain.

According to the Jeju relocation report, not all shrimps could be captured during the relocation period, so an unknown number were left on site and therefore, will ultimately be killed by project activities. Instead, several relocation visits throughout the year should have been conducted to allow maximum capture of shrimps until they cannot longer be observed during surveys.

4.4.2 *Kaloula borealis*

Inappropriate surveys and relocation activities were conducted for the relocation of *K. borealis*. Major concerns include inappropriate timing and length of surveys/relocation visits and lack of adequate searches (e.g., searching for adults within upland habitat). All adult frogs of the endangered *K. borealis* are prone to die as no adult frogs were removed from the construction site. Adult frogs should have been removed during breeding season and a comprehensive search within microhabitats should have been conducted. Relocating adult frogs is essential in the survival of the population.

Construction activities at the navy base directly affected aquatic habitats within the Project Area through destruction of breeding aquatic and upland habitat essential to the survival of the species. Proper, effective surveys and a robust relocation method were crucial to avoid losing breeding individuals essential to correctly relocate the affected population. Construction activities have considerable effects on *K. borealis* including direct killing of individuals and losing an important site for conservation. Based on the removal of 918 tadpoles, the construction site should have also relocated at least 45 female frogs and an unknown number of males (probably 20 minimum), assuming one clutch per female. Therefore, around 65 frogs should have been removed from the construction site, when in fact, none were removed.

The Jeju Civilian-Military Complex Port website* wrote that “about 900 *K. borealis* (Endangered Species, Level II) were transferred to Jeju Stone Park in Jeju City from June to September 2011”, however, it did not specify that in fact, 918 tadpoles and none of the adult frogs were removed. The relocation reports should have discussed the fact that adult frogs were being left onsite, that removal of adult frogs failed, and that killing of all individual *K. borealis* would occur during construction activities.

Searching and relocating of *K. borealis* should have included all life stages, especially adult frogs. The number of visits and survey period for *K. borealis* were inadequate (6 visits within 15 days) and too late (July 2011) when breeding activity had ceased. As a result, only tadpoles were collected and removed. According to photos provided in the relocation report and to the Gosner (1960) staging system for anuran; tadpoles were between stages 32 and 42 indicating that they were well-developed and that egg masses were deposit in the pools at least two weeks prior the first field visits.

Surveys for *K. borealis* should have begun during early May and should have been completed by the end of July. Conducting multiple survey visits throughout the survey-year (especially May through July) increases the likelihood of detecting the various life stages of the *K. borealis* and relocating them. For example, adult frogs are most likely to be detected at night during breeding season (May-end of July) in the vicinity of a breeding location. We recommend a total of up to seventeen surveys to find and relocate *K. borealis* at and near the navy construction site. Three day surveys and seven night surveys are recommended during the breeding season in June, five day surveys in July for tadpoles and two night surveys are recommended prior to the breeding season. Each survey must take place at least three two apart. Once surveys are completed, several searches on potentially impacted upland habitat should be conducted. Extra care should be taken to search and flag burrows, under cover vegetation and under rocks to remove potential remaining frogs.

To locate adult frogs, searches should be made within all types of microhabitat, including at night. The searches for adult frogs were also conducted during an inappropriate time of year, making it very difficult to find and relocate them. Adult frogs should have been surveyed prior to and during the breeding season, rather than afterwards.

Information on type of habitat and microhabitat (e.g., tree holes, burrows, rotten logs, tree buttresses, tree foliages, leaf litter, and isolated pools) should have been delineated and marked where frogs could hide to allow careful searching and removal of the endangered frogs.

*http://jejunavybase.korea.kr/newsWeb/pages/special/jejunavy/news/newsView.do?newsDataId=148731476§ionId=jejunavy_01

Table 2. *K. borealis* surveys and capture flaws and their impacts.

What was done?	Inappropriate method	Impacts on <i>K. borealis</i>	What should have been done?
6 field visits within 15 days	Number of visits and period of field surveys/relocation too short	No adults found. <u>Adult frogs will be killed by construction activities.</u>	17 visits mostly in June during breeding period.
Field visits conducted in late June and July.	Wrong period outside breeding activities.	No adult <i>K. borealis</i> frogs were found, only tadpoles collected. <u>All frogs will be killed by construction activities.</u>	Surveys and relocation must be done from early May to end of July with peak surveys in June.
Mostly daytime visits.	Should focus more on nighttime surveys	Cannot find adult frogs. Only tadpoles observed and captured.	Mostly conduct night surveys during rainy nights.
Dip netting for tadpoles during daytime and traps for adults during night.	Did not include visual searches at night for adults and detailed daytime searches within microhabitat where frogs are likely to hide (e.g., burrows, under deep vegetation etc.).	Cannot find adults and juveniles remaining in upland habitat after breeding season.	Conduct nighttime visual and call surveys during rainy nights + detailed daytime searches within potential microhabitats to locate frogs. Slow and careful digging and removal of natural features should be performed for locating hidden frogs.
No upland surveys	Upland habitat was not surveyed.	Cannot identify frogs hidden in burrows, vegetation, etc. <u>Remaining adult frogs will be crushed by construction activities.</u>	Upland habitat should have been flagged and surveyed for remaining adult frogs.
Survey timing accepted and construction activities started with remaining population of adult frogs on site.	Inappropriate overall survey timing and method.	<u>Same as above and reducing translocation success and establishment of a viable population at Stone Museum.</u>	Should have never started construction activities until upland habitat fully searched and adult frogs are removed.

4.5 Lack of transparency and monitoring issues

No monitoring activities are possible for *C. denticulata keunbaei*; therefore relocation success and failure for this species will remain unknown. By the end of August 2012, monitoring report was still unavailable for *S. intermedium* and *K. borealis*, despite expected submission and public availability.

The monitoring report on *K. borealis* was not available by end of August 2012. Further, Dr. Koh, Dong-hee (Landscape Architect conducting *K. borealis* monitoring) refused to meet the ESI team after several attempts during August 2012 to communicate details of the monitoring program. Due to the lack of transparency, it is sadly impossible to know if monitoring is conducted properly. In addition, no information was available on the number of tadpoles released

at each pond. Field observations of the vegetation along the shoreline of ponds at Stone Park Museum suggested flawed monitoring methods. Indeed, vegetation appeared un-impacted by repeated surveys visits to shorelines.

Monitoring results should be publicly available and monitoring methods assessed by an independent biologist. Monitoring for *K. borealis* started in 2012, whereas metamorphs of this species would ideally be monitored post-relocation in 2011.

Translocation success requires long-term monitoring. Unfortunately, despite the three ponds at Stone Museum being considered of medium to high suitability for relocation, the terrestrial habitat (upland habitat) may limit its success in the future. Predator species and density surrounding the ponds may contribute to this. Data neither exist nor are collected on upland habitat and predators found at the relocation sites are not known. Large populations of competitors and predators include other anuran species, snakes, birds, rats and some aquatic invertebrates. However, due to the lack of preparation before destruction of the original breeding site at the navy base, subsequent translocation of tadpoles was conducted before adequate assessment of the proposed relocation site. The relocation program would have had a higher chance of success if adult frogs were translocated from the upland part of the construction site. Terrestrial habitats are where up to 90% of feeding and growth occurs and consequently, where most frogs are found. Despite this, what constitutes high versus low quality terrestrial habitat remains unknown. However, refuges are essential for *K. borealis* including borrows, under rocks and under cover vegetation. Potential refuges should have been searched appropriately.

5.0 Conclusions and Recommendations

The relocation survival and success of populations depends on adequate reproduction and dispersal. Larval growth and development to metamorphosis is critical for recruiting new breeding adults into the relocated population of *K. borealis* at Stone Museum. Monitoring of metamorphs is essential and should have been conducted in 2011. Since no adult frogs were removed on the construction due to inadequate surveys, construction activities should immediately cease and adult frogs sought in potential microhabitats for relocation to Stone Park Museum.

Due to insufficient development and assessment of monitoring activities at relocation sites, we strongly recommend:

- Immediate cessation of construction activities to avoid further mortality of endangered *K. borealis* and *C. denticulata keunbaeis* at the construction site.
- Allow additional transparent and independent surveys to relocate to the extent possible all boreal digging frogs living in the upland habitat and Jeju Shrimps remaining on construction site.

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- Independently verify relocation methods prior to complete relocation of remaining *K. borealis* and *C. denticulata keunbaeis*. A new suitable site should be selected for relocating *C. denticulata keunbaeis*.
 - Independently verify survey methods of endangered frog and crab monitoring. Follow methods suggested in this report.
 - Provide independent monitoring of the *K. borealis* at the construction site between May-August (wet season). If a *K. borealis* is found during construction activities, work in the area shall stop and a qualified biologist, possessing all applicable permits to relocate this species, will relocate the individual to ponds at Stone Park Museum. Powers to halt construction upon discovery of a frog should be granted and an appropriately qualified biologist made available to carry out necessary relocations.
 - Ensure that degraded areas along Seongwennaek Creek coinciding with *S. intermedium* release are restored and maintained.

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Appendix A

Photographs



Photo 1. Naval base construction site during August 2012.



Photo 2. View of upland habitat at the naval base construction site.



Photo 3. Upstream part of Seongwennaek Creek for *Sesarma intermedium*.



Photo 4. Seongwennaek Creek where *Sesarma intermedium* was released.



Photo 5. Downstream of Seongwennae Creek for *Sesarma intermedium*.



Photo 6. Potential habitat along Seongwennae Creek for *Sesarma intermedium*.



Photo 7. Release site and impacted area along Seongwennaek Creek for *Sesarma intermedium*.



Photo 8. Release site and mouth of Seongwennaek Creek.



Photo 9. Release site for *C. denticulata keunbaei* along Gangjeong Creek.



Photo 10. Gangjeong Creek flowing into ocean.



Photo 11. Suitable pools for *C. denticulata keunbaei* along Gangjeong Creek.



Photo 12. Pond no. 1 at Stone Park Museum.



Photo 13. Pond no. 1 at Stone Park Museum.



Photo 14. Pond no. 2 at Stone Park Museum.



Photo 15. Pond no. 3 at Stone Park Museum.



Photo 16. *C. denticulata keunbaei* observed along Gangjeong Creek.



Photo 17. The endangered *Sesarma intermedium*.



Photo 18. The endangered *Kaloula borealis*