An Independent Environmental Impact Assessment (EIA) of Coral Communities Surrounding the Intended Site of the Gangjeong Naval Base – Including Analysis of Previous Research and Findings

Photo: Courtesy of Jinsoo Kim

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To: Green Peace Korea, Save Jeju Island and Green Korea United

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Table of Contents

1.0 Executive Summary

The purpose of this EIA was to independently assess the health and threats to the unique coral communities in the Gangjeong area, which are threatened by the construction of the Gangjeong naval base. A field site visit was made to Gangjeong on Jeju, South Korea from August 20-25th, 2012. Six days of survey diving were planned but bad weather curtailed this work to the study of only two sites immediately adjacent, east and west of the base construction site. Results from the underwater surveys and a review of existing literature and reports pertaining to the base construction and Jeju's coral populations were used to formulate the following findings and recommendations:

- Construction of the Gangjeong naval base will cause immediate death to thousands of endangered corals by crushing them or smothering them with sediment.
- Long-term sedimentation caused by the construction of the base will reduce food availability and increase stress to the coral populations leading to a decrease in coral recruitment and decline in their health.
- Release of heavy metals and other pollutants into the environment from dredging and filling activities will also stress and potentially kill corals in the areas surrounding the base.
- Reduced and changed current patterns around the base will lead to the demise of the coral populations directly east and west of the seawalls. In addition, changes to current patterns may alter water flow to ecologically important areas such as Train Rock and Tiger Islet.
- Increases in concentrations of the antifouling agents TBT and copper can be expected with increased boat traffic in and out of the base. These biocides inhibit invertebrate reproduction and larval settlement, including corals.
- Small and constant leakages of oils, fuels and other contaminants from machinery into the waters around the base can be expected. Once dispersed by wave action these poisons can adversely affect coral growth and survival.
- Propeller wash from the constant large boat traffic in and out of base has a strong potential to cause physical trauma to ecologically important coral populations around Train Rock.
- Increased sedimentation and pollutants combined with current flow changes and trauma from propeller wash will decrease the coral populations and reduce biodiversity in the area. In addition, coral populations will have a reduced ability to spread to new areas due to loss of habitat from sedimentation and lower reproductive success.
- A major oil leak from the base would cause long-term and possibly irreparable damage to the coral populations in the area.

1.1 Recommendations

- Immediately cease construction of the base because of the threat to the populations of unique and endangered coral populations in the Gangjeong area.
- Conduct another, more comprehensive Navy EIA covering: the effects of heavy metals and other pollutants on coral populations; recent damage by Typhoon Bolaven and future potential storm damage to the site, based on climate change predictions for larger storm activity in the future; and extra work that needs to be completed at the site in order to protect it from storm-related construction damage.
- Do not attempt mitigation of detrimental affects by transplanting corals to other areas, which will fail due to complexity of the supporting environment required for the unique and thriving coral populations in the Gangjeong area.

2.0 Background and Introduction

Since 2002, the South Korean Navy has been planning to construct a 50-hectare naval base on Jeju. Gangjeong, a quiet village on the southern coast of Jeju island, was selected as the site for the base, which is to be home to up to 20 destroyers, submarines and even commercial cruise liners. Touted as an "eco-friendly" base that will bring jobs and security to the region, there has been fierce opposition from local residents who see the base as a threat to their pristine environment and traditional way of life. This is hardly surprising as the base is to be situated very near the buffer zone of the Jeju Island UNESCO Biosphere Reserve and Korean Natural Monument 442, a marine protected area.

An outstanding and significant feature of the marine environment surrounding the proposed Gangjeong naval base site is one of the most remarkable populations of soft corals, also called Octocorals, known in the world. Bathed and fed by rich tropical, warm-water currents, with high flow rates, these corals blanket the rocky habitat, especially the abundant vertical walls, down to depths of 60 m. An exhaustive study by Song (2009) documented 50 species of corals in the area directly surrounding the proposed base. Of the species found, 27 are indigenous, of which national or international law protects 16. The study also documented enormous contiguous populations of soft corals, in some instances as large as 73,000 m^2, within a few hundred meters of the proposed naval base seawall. Given the size and scope of the naval base construction there is little doubt that thousands of endangered soft coral colonies, and numerous associated endangered hard corals and black corals, will perish during its construction. The health and stability of any remaining populations will be seriously impacted by ongoing activities in and around the base once it is operational.

2.1 Recent History of Coral Studies Around the Gangjeong Naval Base Site

- 2007. Jeju Maritime Ecosystem Research Report. This report focused on areas directly adjacent to the naval base construction site and was conducted by Green Korea United.
- 2008. Jeju Navy Base Construction Business Preliminary Environment Review Report (Draft April 2008): Benthic invertebrate animals. This report was the first attempt by the Korean Navy to address environmental impact to the site from construction of the base.
- 2008. Opinion on Prior Environmental Review of the Strategic Environmental Assessment draft on Benthic Invertebrates by the Navy prior to construction of Jeju Naval Base. July 2008. Maritime Biodiversity Research Institute - In the Sea Korea Ltd. This report was commissioned by the Village of Gangjeong to respond to the 2008 Navy EIA. Referenced in this report as INTHESEAKOREA, 2008.
- 2009. Jeju Navy Base (Combined Military and Civilian Tourism Port) Construction Project Environmental Impact Report (Revised). August 2009.

Referenced in this report as Navy EIA, 2009. All references to coral studies in this report are based on the findings of the Seoul National University team who looked at the six sites shown on Map 1.

- 2009. Jeju Coast Soft Coral Reef Coral Distribution Study, Consolidated Report. This comprehensive study was designed to protect cultural properties and document the marine ecosystem through detailed research of soft coral communities along the Seigwipo coast, especially in the natural monument 442 area. This work was conducted between 2006-2009 and was not related to construction of the naval base. Referenced in this report as Song, 2009.

2.2 Purpose of the Current Report

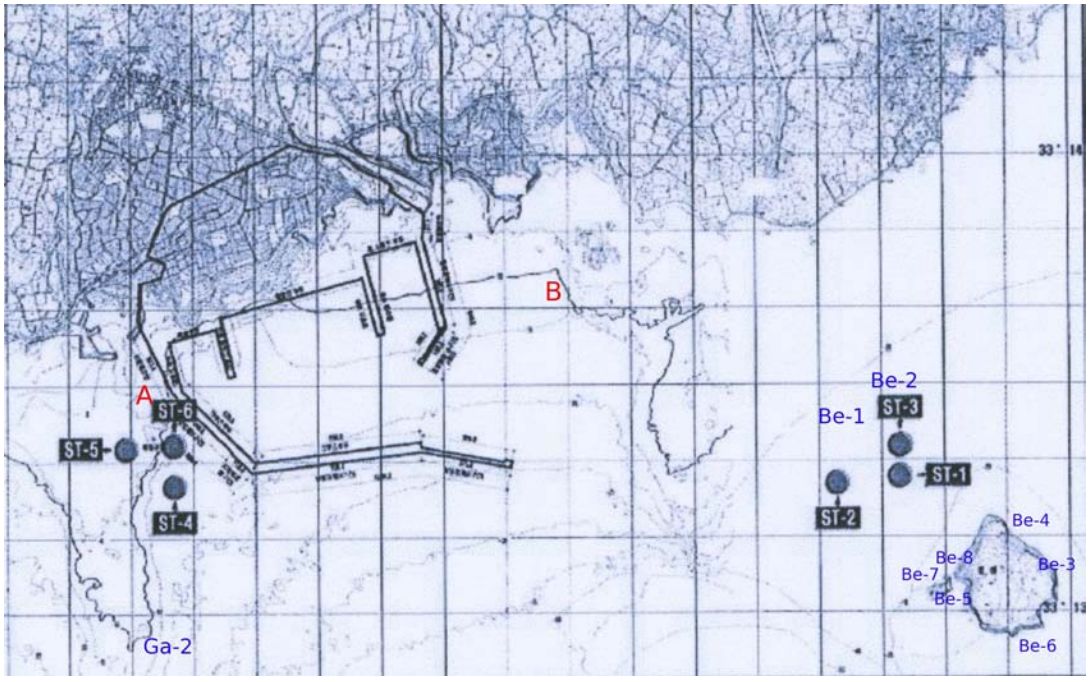
1. Conduct dive assessments of sites close to the Gangjeong naval base construction site previously not assessed by other reports.
2. Review and collate existing information on coral communities around the naval base construction site.
3. Draw conclusions as to the short-term and long-term damage to coral communities posed by construction and use of the Gangjeong naval base.

3.0 Methodology

3.1 Dive Surveys

Six days of diving had been originally scheduled for the surveys. This was reduced to just 2 days due to bad weather. On day one of the dive surveys, meetings were held with the dive team which included: dive team leader Mr. Jingsoo Kim; Sang-Hoon Yun (Green Korea United); Simon Ellis; and two local support divers. As the weather was turning bad it was decided to test equipment and techniques on day 1 at Train Rock and Tiger Islet. The following day there would be two dives at two key sites close to the naval base: one at the lighthouse on the west side of the construction site (site A on map 1); and one site close to a small islet to the east of the construction site (site B on Map 1). Both sites are shallow (maximum depth 20 m) but have vertical walls on which soft corals are abundant. These sites were chosen because they were accessible and are close enough to the proposed base site to almost certainly be impacted by the construction.

Corals were quantified using four 50 cm^2 quadrats placed 3 m apart at depths of 9 and 12 m. In addition a search was made of the area to look for species that were not recorded in the quadrats. Video footage of key areas of each site was also taken.



Map 1. Sites surveyed during this study (A and B) in relation to the outline of the completed naval base and sites surveyed during the Navy EIA (ST-1, ST-2, ST-3, ST-4, ST-5, ST-6) and sites surveyed by Song (2009) (Ga-2, Be-1, Be-2, Be-3, Be-4, Be-5, Be-6, Be-7, Be-8). Stations Be-1, Be-2, ST-1, ST-2 and ST-3 are all located at Train Rock.

Figure 1. Site A entry point. Gangjeong port can be seen in the background and the start of the orange silt screen for the base on the right side.

Figure 2. Site A exit point. Again showing lighthouse, Gangjeong dock in the background and silt screen on the right side.

Figure 3. Site B was located on the other side of this small islet. The base silt screen can be seen on the right side.

3.2 Other Data Collection

In addition to the dive surveys, visits were made on land to both ocean side perimeters of the construction site in order to get a sense of the location of the base in relation to the dive sites and existing key soft coral populations. Personal interviews were also conducted with the following people: Mr. Jinsoo Kim, dive guide with over 7000 dives in the area; Mr. Jong rak Lee, author of the 2008 INTHESEAKOREA report; and Mr. Gwonil Goh, chief of the Gangjeong Village Committee, who has studied the intended base construction site and methods extensively. All of these individuals provided valuable information and context for this report.

4.0 Dive Survey Results

Site Description	Gangjeong Lighthouse	Rock E. of Construction
GPS Location	33°13′326″N 126°28′829″E	33°13′657″N 126°29′777″E
% coral cover at 9 m	16%	6.3%
% coral cover at 12 m	34%	8.5%
Species or Genus	***Present***	***Present***
Order Alcyonacea		
Dendronephthya gigantea	Yes	Yes
Dendronephthya putteri (1)	Yes	No
Dendronephthya suensoni (1)	Yes	No
Dendronephthya mollis (1)	Yes	No
Scleronephthya gracillima	Yes	Yes
Acabaria formosa	Yes	Yes
Euplexaura crassa	Yes	Yes
Calicogorgia granulosa	Yes	Yes
Verrucella spp.	Yes	Yes
Order Antipatharia		
Myriopathes japonica (1,2,3)	Yes	Yes
Order Scleractinia		
Montipora trabeculata (3)	Yes	Yes
Alveopora japonica (3)	Yes	Yes
Dendrophyllia spp. (3)	Yes	Yes
Tubastrea coccinea (1,3)	Yes	Yes

1. Korean Ministry of the Environment Endangered Animal or Plant; 2. Protected by the Cultural Heritage Administration Natural Monument 456; 3. Convention on the International Trade in Endangered Species (CITES) Appendix II.

Site Descriptions

A. Gangjeong Lighthouse

A total of 14 species of corals were found during this dive ranging from 0-15 m in depth. Of these 14 species, 8 are protected by national or international law. Of particular interest was a dense grouping of colonies of the endangered *D. putteri.* The 9 m transect was on the lower edge of the kelp forest. Individual gorgonians and *D. gigantea* were interspersed among the kelp. At the end of the transect, a large bed of *S. gracillima* interspersed with *D. gigantea* was found. The 12 m transect, because it was below the kelp forest, had a much higher percentage cover of soft corals (34%). The population was predominantly *S. gracillima* interspersed with *Dendronephthya spp.* and gorgonians. Scleractinian corals were found at both transect depths.

B. Seogeondo Rock, East of Construction site

A total of 11 species of corals were found during this dive ranging from 0-20 m. Of these 11 species, 5 are protected by national or international law. Coral densities in the transects were not high, and at both depths, were dominated by the

Scleractinian coral *Alveopora japonica*. Toward the end of the dive however a dense bed of *S. gracillima* was discovered stretching southward toward Train Rock, also known as the Coral Garden.

Figure 4. *Dendronepthya gigantea* (top, purple color) and *Scleronephthya gracillima* (bottom, orange color), the two most abundant members of the Alcyonacea at the two sites.

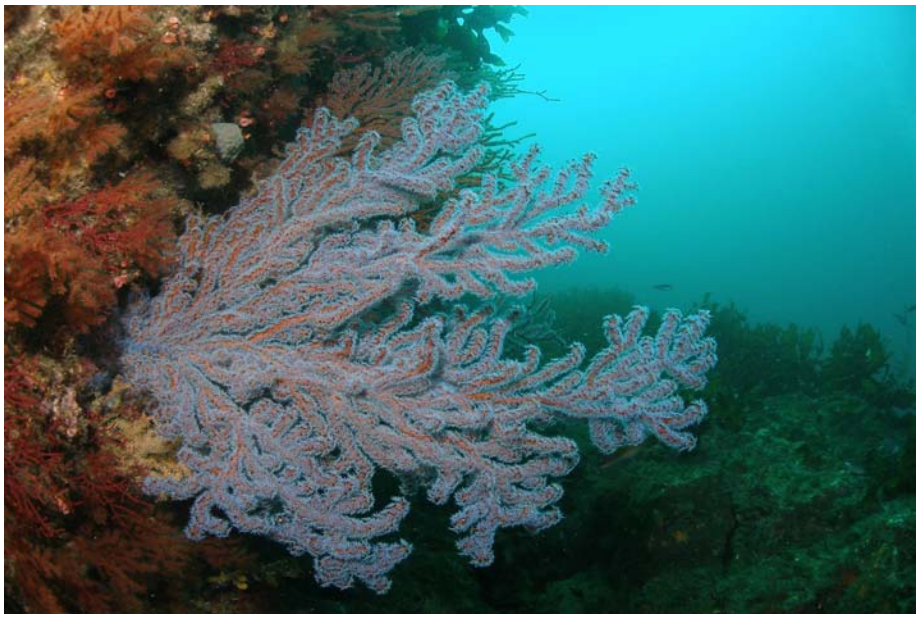


Figure 5. *Calicogorgia granulosa* found at both sites.

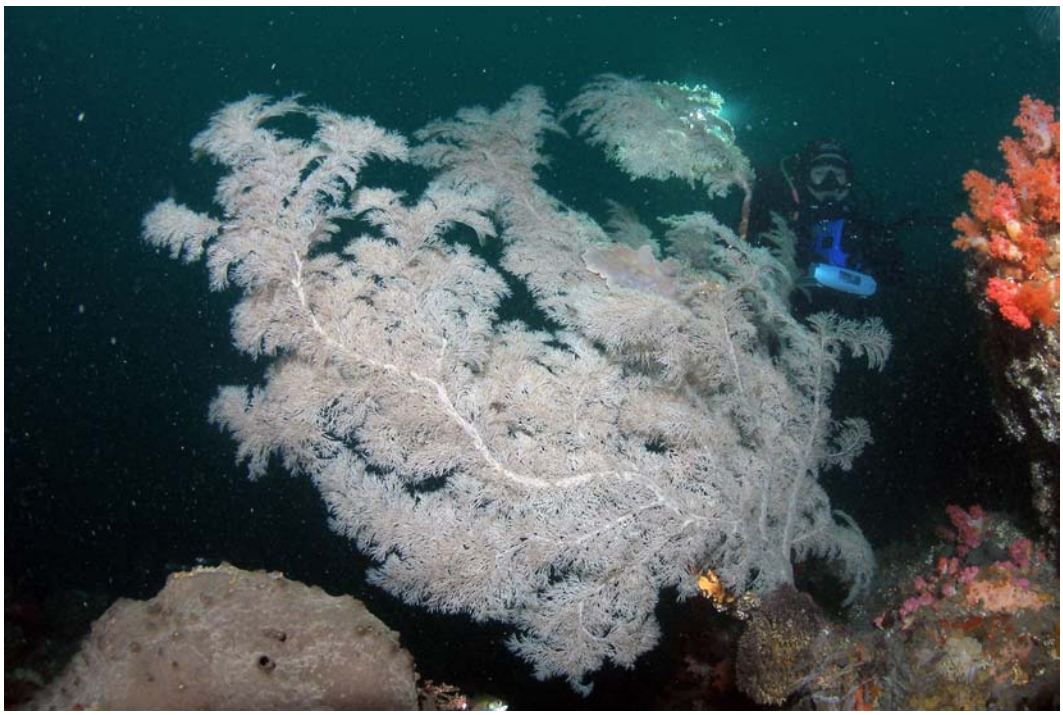


Figure 6. ***Myriopathes japonica,*** **a protected species.**

Figure 7. ***Tubastraea coccinea,*** **a CITES Appendix II listed species.**

Figure 8. ***Alveopora japonica,*** **a CITES Appendix II listed species.**

5.0 Discussion

5.1 Survey Site Coral Populations

The species density and cover at the two sites surveyed are not high compared to other sites, which are further from the base. This is most likely because both sites are shallow and quite close to the shore making them susceptible to runoff and sedimentation. The species diversity and number of endangered species found is in keeping with other surveys of sites closer to shore. Song (2009) documented only 18 species at an inshore site (Oe-1), which was much deeper (32 m) than the sites surveyed in this study. The Navy EIA (2009) studied two sites very close to the Gangjeong lighthouse also and found only 19 species at one site and 13 at the other. What is important about both sites surveyed in this study is that significant numbers of endangered and protected species were found at both sites and, because they are so close to the construction site, that they are almost certain to be severely impacted by the construction of the base.

5.2 Coral Populations Around the Base Construction Site

Both the Navy EIA (2009) and Song (2009) documented large, diverse areas of soft corals within 1-2 km of the base construction site. Both reports claim these populations to have great ecological significance and conservation value. All of these coral populations may be severely impacted by the base construction, and subsequent base operations, as discussed below. Song (2009) found 50 species, 27 indigenous species and 16 endangered species from 9 sites. Eight of these sites were around Tiger Islet and the Train Rock (or Coral Garden) area (Map 1) and one site, which was 1.5 km south of the Gangjeong lighthouse. In this report, the Train Rock coral population area is reported to be 73,800 m^2 in area and ranked as a level V (highest priority) area to conserve. This area is just 2 km from the proposed naval base eastern seawall.

The Navy EIA (2009) documents surveys at two main locations: one south of the Gangjeong lighthouse; and the other around Train Rock (called Gichabawi Rock in the report). At each location 3 sites were surveyed. A total of 40 species of corals, spread among 8 orders, 19 families and 26 genera, were found between the two sites. Of the species found the Navy EIA (2009) lists only 9 species as being protected by law. The Navy EIA (2009) also omitted to mention 3 genera of hard corals (known as Scleractinian corals), found at their test sites, which are protected by the Convention on the International Trade in Endangered Species (CITES) Appendix II, namely *Montipora spp., Alveopora spp*. and *Dendrophyllia spp*. The Navy EIA (2009), like the Song (2009) report, recognized the importance of the Coral Garden (Train or Gichabawi Rock area) as follows:

"*In summary, Gichabawi Rock is deemed to have an important ecological habitat location and function in southern Jeju waters in terms of anthozoa diversity and*

biological quantity. When marine organisms (soft corals, in particular) release spores or enter the larval breeding stage, spores and larvae will move anywhere from tens to hundreds of kilometers, swept along by sea currents, which is why Gichabawi Rock and Gangjeongdeungdae Lighthouse did not show any significant marine biotic differences compared to nearby Munseom and Beomseom Islands. However, some protected species with a high appearance frequency boost the conservation value of Gichabawi Rock anthozoans, thus necessitating prudent judgment and decision."

In addition the Navy EIA (2009) also concluded as to the vulnerability of the Gichabawi Rock as follows:

In terms of anthozoa distribution, Gichabawi Rock is inhabited by as many protected species as Munseom and Beomseom Islands, with the species count being similar, while the appearance frequency of some protected species (Dendronephthya suensoni , Antipathes sp.) was greater than those in Munseom and Beomseom Islands. Our dual survey in 2009 revealed that only in Gichabawi Rock were protected soft coral species not discovered, but given its proximity to the projected naval base construction site, if the habitat were damaged, the number of internationally protected organisms, including Antipathes sp., would experience a decline in their numbers.

A third report, produced by INTHESEAKOREA (2008), was commissioned by the Gangjeong Village committee in response to the Navy EIA (2008) report. This report was critical of the Navy EIA (2008), stating that there were numerous errors in research methodology and, subsequently, the omission of important information on the ecological characteristics and species composition of the area.

5.3 Effects of Construction of the Gangjeong Naval Base on the Surrounding Coral Communities

5.3.1 Damage During Construction Phase

a. Destruction of living corals.

The naval base construction area and seawalls will cover more than 50-ha once completed. There is no report on what kinds of coral populations inhabit the base construction area and access is now denied. The bottom habitat around the base is sandy with a combination of large and smaller boulders. The Navy EIA (2009) indicated the presence of the endangered species *Dendronephthya suensoni* on boulders at 18-22 m around the Gangjeong lighthouse, less than 500 m from the construction site. In addition, a total of 7 endangered or protected coral species are found in that area. It is likely therefore that *D. suensoni* and other endangered corals inhabit the construction zone. The Navy EIA (2009) also goes on to state that corals at sites S4-6 (Map 1) around the Gangjeong lighthouse "are forecast to suffer direct and adverse environmental impacts as a result of the construction work." If this is the fate of the corals in the vicinity of the construction site, it is fair to assume the same fate or worse awaits those corals inhabiting the construction zone. Aside from the seawall construction, which will kill everything underneath and around it, there

will be significant, or near total mortality, to benthic organisms from dredging and sedimentation within the base construction site. This will amount to many thousand, and perhaps even millions, of endangered coral colonies.

b. Sedimentation

Sedimentation at the naval base construction site may come from run-off from exposed land sites or ocean-based dredging or depositing fill for construction of the seawalls. Sedimentation has multiple effects on living plants and animals, including corals, mainly relating to the fine particles that result from these activities. These particles can remain suspended in the water column for many days. The most obvious effect of sedimentation is the permanent covering of substrates as discussed above. Animals and plants are unable to respire or feed and eventually die of starvation and suffocation. However, many other effects of sedimentation affect or kill marine organisms. Clouds of fine particles also stop sunlight entering the water, affecting photosynthesis by phytoplankton and macroalgae. Most of the corals in the Jeju area are non-photosynthetic and hence rely heavily on phytoplankton for food (Fabricius et al. 1995). Sedimentation can cut down their food supply and may eventually stunt growth or lower their survival rate. For corals having symbioses with photosynthetic zooxanthellae, the shading effect of the suspended sediment can reduce zooxanthellae nutrients and cause death of the coral. Thus, constant re-suspension of particles inside and around the base construction site is likely to eventually kill any corals that have not already been killed by the direct trauma of dredging, fill deposit or wall construction. Other, longer-term effects of sedimentation on the area are discussed below.

The Navy EIA (2009) report contains details of many mitigation measures that are to be used during the construction phase of the base. These include the use of silt screens (Figure 9). Conducting sedimentation monitoring outside of the screen could test how well the silt screens are working but this is currently not happening. Evidence of the silt screens not remaining intact has also been discovered. During moderately heavy seas on August 23rd, part of a silt screen from the base was seen floating off Tiger Islet (Figure 10). Another mitigation measure that was mentioned in the EIA is use of fall pipes for laying riprap or fill. Fall pipes are tubes that reach down to the ocean floor for delivering fill to the bottom. Using these pipes reduces fine particles entering the water column from the fill material. However, Figure 11 shows fill being dumped directly into the water rather than using fall pipes. Other mitigation measures from the Navy EIA (2009) report included washing of riprap before depositing it in the ocean and also reducing the "footprint" of the seawalls so they cover less area on the seafloor. It cannot be verified at present how or when these measures are to be implemented. However, the fact remains that even if all these measures are implemented, corals within 500 m of the construction zone will still suffer direct and adverse environmental impacts according to the Navy EIA (2009) report. As it is evident that some of these measures are right now not being properly implemented it can be expected that the construction phase of the base will negatively impact coral populations much further away than 500 m from the construction zone.

Figure 9. Silt screen around the base. Tiger Islet and floating caissons (since badly damaged by Typhoon Bolaven) can be seen in the background.

Figure 10. Silt screen torn loose from the construction site during moderately high seas on August 23rd, 2012.

Figure 11. Barges placing fill or riprap on the sea floor at the construction site.

c. Release of Toxins from Sediments

The construction of the Gangjeong naval base is likely to release a number of toxic chemicals, namely heavy metals and persistent organic pollutants into the water column. Whenever sediment is dredged or moved, pollutants that have been previously bound or adsorbed to the substrate are released into the water column, often in much more toxic or freely available forms (Jones et al., 1981; Goosens and Swlozman, 1996). These toxins include heavy metals such as Lead, Mercury, Cadmium, Copper, Nickel and Zinc. As these metals are removed from the sediment, their chemical binding changes, sending them into a "free" state when they can be easily taken up by animals, such as corals. The ability of corals to absorb, and be adversely affected by these toxic metals is well documented (Shah, 2008; Mohammed and Dar, 2012).

Sediments around the Gangjeong naval base are quite rich in heavy metals due to the volcanic nature of Jeju island (Navy EIA, 2009). Over thousands of years, rainfall and erosion have delivered heavy-metal-laden sediments into the sea around Jeju. When these sediments are dredged, these metals will become more bioavailable to the benthic communities around the base and will be absorbed by the coral populations with deleterious effects. This will not only affect coral populations but will also poison edible shellfish and will accumulate in fish populations, posing a risk to human health. The Navy EIA (2009) addressed the issue of heavy metals but two key heavy metals, Mercury and Arsenic, were not measured in the sediments around the Gangjeong naval base construction site. The heavy-metal content of the

sediment as measured in the Navy EIA (2009) is high enough to be highly toxic to marine life, once released into the water column.

d. Storm damage during construction
The base construction site has shown itself to be highly vulnerable to storm damage, as evidenced by Typhoon Bolaven. On August 28th, 2012, this storm battered Jeju with winds exceeding 40 m/s. On August 23rd, moderate seas had already torn loose parts of the silt screen (Figure 9.). During the storm 7 floating caissons, used in construction of the sea wall (Figure 10, background) were heavily damaged by the storm and two of them broke free and sank. In addition to the enormous cost to repair or remove the broken caissons there is also a substantial cost to the environment. The sunken caissons will have damaged coral and other benthic populations in and around the base. At present there is every indication that inadequate precautions have been taken by the base construction team to ensure the protection of the environment during the construction phase of the project.

5.3.2 Damage During Ongoing Operation

a. Sedimentation
Sedimentation is perhaps the most long lasting and insidious effect of construction that requires land clearing, dredging or deposit of fill materials, such as at the Gangjeong naval base. If the base is constructed to completion, effects of sedimentation are likely to continue for years afterward. Fine silt left from the construction might remain in the area for years, getting stirred up into the water column whenever there are rough seas or large waves. This silt physically acts in two ways: first to shade the water column, thereby reducing photosynthesis by phytoplankton and macroalgae; and secondly to coat benthic organisms, including corals, with fine particles. This stresses the corals and increases their energy budget, as they have to constantly produce mucus to remove the silt. The combined stress can greatly reduce growth and survival of corals and eventually kills them. Reduced populations of phytoplankton will also lead to reduced population of zooplankton, which feed, on the phytoplankton. Most of the coral species found in the Jeju area feed both on phytoplankton and zooplankton and would therefore be adversely affected.

A second problem from persistent siltation is that it coats rocks onto which coral larvae may settle. This will prohibit settlement of new colonies and will affect regeneration of coral populations in the foreseeable future. Sedimentation is related to other deleterious long-term effects of construction of the base as described below.

b. Water flow rates
Strong current and water flow are essential to the growth and survival of non-photosynthetic soft corals (Fabricius et al. 1995; Mr. Jinsoo Kim personal communication), such as those that occur around the naval base site. This is because the water carries necessary food and nutrients to the immobile corals.

Depending on ambient currents, they are generally highly abundant in flow-exposed habitats, and absent in flow-protected habitats. If the direction and speed of those water currents are changed, the coral populations in the area can be expected to change. Flow is important not just for food, but for distribution, rates of gas exchange, colony growth and size. Also when water currents are slowed or impeded there can be sedimentation as fine particles drop out of suspension in the water column.

Without a full oceanographic study of the area, it is hard to say what will happen to current patterns around the Gangjeong naval base once it is completed. However, a preliminary study of the topography of the area and proposed location of the base seawall indicates that there will very likely be a significant drop in current flow rates around the two sites surveyed in this study (A and B, Map 1). When this happens, the corals in the area will receive less food and nutrients with the predictable result that they will eventually die out. At site B there is the added stressor of the Gangjeong stream running into the ocean east of the base seawall. Lack of ocean current in this area may cause sediment from the stream to drop down quickly, smothering benthic populations.

In addition to lower currents directly adjacent to the base the intrusion of seawalls into the ocean will change flow patterns. Eddies and gyres may be set up and large amounts of water may be deflected away from Train Rock and the Tiger Islet. If this happens coral populations and densities around these ecologically significant areas may be altered for the worse.

The Case Study of Seogwipo Harbor

The Navy EIA (2009) uses a case study of Seogwipo harbor as a comparison of what will happen during the construction of the Gangjeong naval base, claiming that sedimentation has not been a problem and that soft coral populations are expanding around the harbor area. Of the two study sites chosen for temporal comparison one was just were south of the harbor mouth and the second was around Munseom Island, an area particularly rich in coral life.

Looking more closely at the topography of the area it makes senses that these populations would remain healthy and, as stated in Navy EIA (2009), actually expand. The new construction on the Seogwipo harbor walls extended them out further south than before, lessening the gap between the harbor wall and Munseom Island, increasing the current speeds, and favoring new growth of soft corals there (Park and Kang, 2010). Strong current in these areas could also be expected to wash away fine sediment that might smother the corals.

Of greater interest would be some comparison of coral growth west and north, in the “shadow” of the harbor wall. Song (2009) surveyed an area north west of the harbor breakwater in 2006, finding relatively low percentage coral cover (<20% with the exception of one depth). In addition, the INTHESEAKOREA (2008) report stated that serious sedimentation was occurring on the west and east sides of the

harbor breakwaters and that the benthic life, including soft corals, was being seriously affected.

The Seogwipo harbor case study, rather than putting a positive light on the construction of the Gangjeong naval base, instead only highlights that the construction will condemn thousands of endangered corals to death and will significantly alter coral populations and health around the base, permanently.

c. Organotin pollution

Organotin products especially Tri-butyl Tin (TBT) have been used as highly effective anti-fouling paints since the 1960's. These chemicals cause death of fouling organisms at the time of settlement. Highly effective co-polymer paints have been developed that have a "self-polishing" action where new layers of toxic antifoulants are constantly exposed. These paints can be effective for as long as 60 months (Champ and Pugh, 1987; Callow, 1990). Development of these paints made TBT a persistent organic pollutant, which was being leaked into the environment wherever ships were, especially in harbors. Estimates are that that a large ship such as a navy destroyer can add 200 g of TBT into the environment over a 24-hour period (Birkett and Lester, 2003).

So stable is TBT as a biocide in the environment, it can remain unaffected for between 7 and 30 years, especially in anoxic conditions such as those found in sediments (Bray, 2006). In oxic conditions TBT degrades into the less toxic dibutyltin and finally monobutyltin in 1-3 months (Cornelis, 2005). Once in the environment TBT acts to affect larval settlement and development and also disrupts reproduction in gastropods and other invertebrates. Corals and coral reproduction are also affected by TBT (Negri and Heyward, 2001; Smith et al., 2003).

The International Maritime Organization proposed a total ban on TBT from 2003 to be fully in place by 2008. However, this has only been partially effective as large military vessels are still permitted to use TBT based paints (Navy EIA, 2009). In Korean waters, highest concentrations of TBT have been found at locations close to areas of intense ship traffic (Choi et al., 2008). Given that TBT and copper based antifouling paints will be used on ships using the Gangjeong naval base, coral populations in the vicinity will be negatively impacted. Coral reproduction and recruitment (settlement of new corals) will be severely restricted by these chemicals as they leach into the water, accumulate and remain active.

d. Propeller wash

Most of the corals inhabiting the Jeju area are soft bodied and are easily damaged, even by water turbulence. There is a strong possibility that soft coral populations will be severely damaged by propeller wash from vessels leaving and entering the Gangjeong naval base. The top of Train Rock is only 14 m below the surface and many naval vessels have a draft of 10 m or more. Therefore is can be expected that there will be trauma and mortality to ecologically important coral populations from the constant passing of large ships.

e. Fuel and oil spills

Fuel, oil and other organic hydrocarbons can have serious effects on marine benthic organisms, even in small quantities. Corals are especially vulnerable to dispersed oils, especially lighter fuels such as gasoline, diesel and light crude. Other fluids associated with engine maintenance and function, such as antifreezes, lubricants and detergents, are also harmful. Dispersal is greatly increased by heavy wave action similar to that seen along the southern Jeju coastline. Thus, even minor spills of oil and fuel will have a major affect on the coral populations surrounding the Gangjeong naval base. It is highly likely that once the base is operational there will be a constant release of small amounts of fuel into the environment. Though relatively minor, this contamination will have long-term negative effects on surrounding coral populations already stressed by other factors such as sedimentation, reduced flow and pollutants such as TBT and other heavy metals.

Should there be a major spill or oil from the base site, the ramifications would be even worse, possibly leading to mass mortality in coral populations. Oil coatings on rocks and beaches could take years to dissipate leaving affected coral populations unable to recover.

5.4 Mitigation Measures

The reasons for the existence of coral populations of such important ecological significance in the Gangjeong area are: a unique mixture of tropical currents, an ideal rock substrate and a healthy environment. Because of this irreproducible combination of natural factors, it is not recommended that any mitigation through transplanting be attempted. Prior attempts to transplant corals around the Seogwipo harbor were a failure. Future attempts are also likely to be futile and a waste of money and effort. Instead it is vitally important to maintain the area in its pristine state without disturbance by the construction of the base.

6.0 Conclusions

- Construction of the Gangjeong naval base will cause immediate death to thousands of endangered corals by crushing or smothering them with sedimentation.
- Long term sedimentation caused by the construction of the base will reduce food availability and increase stress to the coral populations leading to a decrease in recruitment and decline of health.
- Release of heavy metals and other pollutants into the environment from dredging and filling activities will also stress and potentially kill corals in the areas surrounding the base.
- Reduced and changed current patterns around the base will lead to the demise of the coral populations directly east and west of the seawalls. In addition, changes to current patterns may alter water flow to ecologically important areas such and Train Rock and Tiger Islet.
- Increases in concentrations of the antifouling agents TBT and copper can be expected with increased boat traffic in and out of the base. These biocides inhibit invertebrate reproduction and larval settlement, including corals.
- Small and constant leakages of oils, fuels and other contaminants into the waters around the base can be expected. Once dispersed by wave action these poisons can affect coral growth and survival.
- Propeller wash from the constant large boat traffic in and out of base has a strong potential to cause physical trauma to ecologically important coral populations around Train Rock.
- Increased sedimentation and pollutants combined with current flow changes and trauma from propeller wash will decrease the coral populations and reduce biodiversity in the area. In addition, coral populations will have a reduced ability to spread to new areas due to loss of habitat from sedimentation and lowered reproductive success.
- A major oil leak from the base would cause long-term and possibly irreparable damage to the coral populations in the area.

Recommendations

- Immediately stop construction of the base, which threatens the populations of unique and endangered coral populations in the Gangjeong area.
- Conduct another, more comprehensive Navy EIA covering: the effects of heavy metals and other pollutants on coral populations; recent damage by Typhoon Bolaven and future potential storm damage to the site, based on climate change predictions for larger storm activity in the future; and extra work that may need to be completed at the site in order to protect it from construction-related storm damage.
- Do not attempt mitigation by attempting to transplant corals to other areas, which will fail due to the irreproducible complexity of the supporting

environment required for the unique coral populations in the Gangjeong area.

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